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DIGITAL SIGNAL TRANSMISSION SYSTEM AND METHOD OF DISPLAYING TRANSMISSION CONDITION IN DIGITAL SIGNAL TRANSMISSION SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a digital signal transmission system using a digital modulation system such as orthogonal frequency division multiplex

5   (OFDM) modulation system.

In recent years, European countries, the United States of America, and Japan have already put digital broadcasting into operation or some of them are considering digital broadcasting. The OFDM modulation

10 system is regarded as the most likely prospect for digital broadcasting.

This OFDM modulation system is a kind of multi-carrier modulation system, and is the sum of a large number of digitally modulated carrier waves. In

15 addition, each carrier is modulated by QPSK (Quadrature Phase Shift Keying), and the resultant wave of all the modulated carriers is the OFDM signal.

Here, for the OFDM signal, first the QPSK signal, $\alpha_k(t)$ of each carrier can be expressed by the

20 following equation.

$$\alpha_k(t) = a_k(t) \cdot \cos(2\pi k f t) + b_k(t) \cdot \sin(2\pi k f t) \quad \dots\dots\dots(1)$$

where k is the carrier number, and $a_k(t)$, $b_k(t)$ are data of k-th carrier and take a value of -1 or 1.

If the number of carriers is N, the OFDM signal is the resultant of N carriers. If this OFDM signal is represented by $\beta_k(t)$, it can be expressed by the following equation (2).

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$$\beta_k(t) = \sum \alpha_k(t) \qquad (k=1\sim N) \quad \ldots\ldots\ldots\ldots(2)$$

Incidentally, in the OFDM modulation system, it is common practice to add a guard interval to each signal unit in order to reduce the multi-path effect.

The OFDM signal is formed of those signal

10 units. The symbol of this signal unit is formed of, for example, 1024 effective samples plus 48 samples of guard interval data, or 1072 samples. Also, a stream unit called frame is the sum of 892 symbols and 6 synchronizing symbols, or 900 symbols in total. These

15 stream units are repeated as the OFDM signal.

Fig. 17 is a block diagram of the basic constructions of the modulator and demodulator in a conventional OFDM transmission system. The trans- mission-side T_x construction has a transmission-side

20 processor 101 that includes a transmission path coder 1T, an encoder 2T, an IFFT (Inverse Fast Fourier Transform) 3A, a guard adder 3B, a synchronizing symbol inserter 5, a clock oscillator 6, and an orthogonal modulation processor 8, and a transmission antenna A_{TX}.

25 The receiving-side R_x construction has a receiving antenna A_{RX} and a receiving-side processor 203 that includes an AGC 9A, an orthogonal demodulation processor 9B, a synchronizing detector & correlator 4A,

an FST corrector 4B, an FFT (Fast Fourier Transform) 3C, a decoder 2R, a transmission path deencoder 1R, and a voltage controlled clock oscillator 10. These transmission-side T_x and receiving-side R_x are connected by, for example, a wireless transmission path L using radio waves.

The modulation and demodulation processes for OFDM signal will be described with reference to Fig. 17.

Data D_{in} that is continuously supplied to the transmission path coder 1T of the transmission-side processor 101 is, for example, processed for each frame that is formed of 900 symbols. During this frame period, 894 information symbols other than 6 synchronizing symbols, each including 800 samples ranging from the first to 400-th and from the 625-th to 1024-th samples, are processed and produced as intermittent rate-converted data D_{ii}.

The transmission path coder 1T also generates a transmission-side frame control pulse FST at each frame of 900 symbols, and supplies it to other elemental blocks as a frame pulse signal that indicates the start of those synchronizing symbol periods.

The encoder 2T codes the input data D_{ii} into data R_f and I_f that are mapped on the two axes of I and Q.

The IFFT 3A regards these data R_f and I_f as frequency components, and converts them to time base

signals R (real part) and I (imaginary part) of 1024 samples.

The guard adder 3B adds after the 1024 samples the waves of, for example, the first 48 samples

5 of the waves in the start period of the time base signals R and I of 1024 samples, and produces information symbols R_g and I_g of time base waves of a total of 1072 samples. These 48 samples serve as a protection band when reflected waves are mixed.

10 The synchronizing symbol inserter 5 inserts, at every 894 in these information symbols R_g and I_g, samples synchronizing waves of 6 symbols that are previously stored in a memory to produce data R_{sg} and I_{sg} of frames.

15 These data R_{sg} and I_{sg} are supplied to the orthogonal modulation processor 8, where they are processed by a D/A converter 81, orthogonal modulator 82 and local oscillator 83 so that an OFDM modulated signal RF with a carrier of high frequency F_c can be

20 produced, amplified and transmitted through the transmission antenna A_{TX} to the transmission path L. The transmission frequency band used is UHF band or microwave band.

The clock CK (of which the frequency is 16

25 MHz) necessary to process in the transmission side T_x is supplied from the clock oscillator 6 to each block as a transmission side clock CK_d.

The OFDM modulated signal RF transmitted as

above is supplied to the orthogonal demodulation processor 9B via the receiving antenna A_{RX} and via the AGC 9A that handles high frequencies on the receiving side R_x. In the orthogonal demodulation processor 9B,

5 an orthogonal modulator 91 multiplies the OFDM modulated signal RF by a local oscillation signal of frequency F_c' that is fed from a voltage controlled oscillator 93, thus orthogonally demodulated into the base band signal, and then an A/D converter 92 converts

10 it to the digital data R'_{sg} and I'_{sg}.

These data R'_{sg} and I'_{sg} are supplied to the FFT (Fast Fourier Transform) 3C, which then responds to a pulse signal FST_{rc} to produce a gate signal that is used for FFT and determines the data period of the 1024

15 samples. That is, the time base wave signals R'_{sg} and I'_{sg} are converted to frequency component signals R'_f and I'_f by removing the 48 samples for the protection band.

These frequency component signals R'_f and I'_f are supplied to and decoded by the decoder 2R into data

20 D'_0, which is then further decoded by the transmission path decoder 1R into continuous signal D_{out}.

The data R'_{sg} and I'_{sg} are also supplied to the synchronous detector & correlator 4A, where a synchronizing symbol group is detected from the data. Thus,

25 the pulse FSTr is derived therefrom as a frame pulse. This pulse FST_r is supplied to each block of receiving side R_x as a frame control pulse.

In addition, this synchronous detector &

correlator 4A compares the synchronizing components of the data R'_{sg} and I'_{sg} with the clock CK_{rc} generated from the voltage controlled clock oscillator 10, and produces a correlation output S_c according to the

5 comparison result, and supplies it to the FST corrector 4B. The FST corrector 4B generates a control voltage VC, thus controlling the voltage controlled clock oscillator 10 to generate the clock CK_{rc} with a correct period, which is then supplied to each block of the

10 receiving side.

Each block shown in Fig. 17 will be described in detail.

The transmission path coder 1T makes inter-leave processing, energy dispersion processing and

15 error correction code processing in order to prevent data from being erroneous due to different kinds of error that may be mixed during the transmission.

The encoder 2T converts the signal D_{ii} to information at predetermined points on the I and Q axes

20 by use of the data stored in a mapping ROM, and replaces the signal of the period corresponding to unnecessary carrier by 0 to produce data R_f and I_f.

The IFFT converter 3A converts the input signals R_f and I_f to the time base waves R and I of the

25 symbol period determined by the clock CK_d and pulse FST. Specifically, this IFFT converter may be the PDSP16510 made by Pressy corp. or the equivalent.

The guard adder 3B is formed of a delay

circuit for delaying the input signals R and I by 1024

samples, and a switch for selecting only the delayed

output from 1025-th sample to 1072-nd sample. These

timings are determined by the clock CK and pulse FST.

5   The time base waves ranging from the first sample to

the 48-th sample are added to the range from 1025-th

sample to the 1072-th sample, of the symbol that is

formed of all 1072 samples, to form information symbol

R_g and I_g.

10   Fig. 18 shows one example of the synchroniz-

ing symbol inserter 5. First, ROMs 5-1 and 5-2 are

controlled by a controller 5-5 of which the operation

timing is determined by the clock CK and pulse FST, so

that a synchronizing symbol signal can be generated in

15   accordance with the timing of the pulse FST.

          Similarly, SELs 5-3 and 5-4 are controlled by

a controller 5-6 of which operation timing is deter-

mined by the clock CK and pulse FST, so that the

synchronizing symbol signals read from the ROMs 5-1 and

20   5-2 are selected only during the period from the first

symbol to the sixth symbol that is a non-signal period

at the present stage, of the time base information

symbol signals R_g and I_g with guards.

          Here, the synchronizing symbol signals

25   include, for example, null (NULL) symbols for roughly

finding the existence of the synchronizing symbol group

that is in non-signal state during one symbol period,

special symbols (hereinafter, referred to as CW symbol)

having only one carrier during one symbol period, sweep (SWEEP) symbols that are waveforms changing from the lower limit to upper limit of the transmission frequency band during one symbol period, and for

5 correctly finding the points of symbol switching, and reference symbols indicative of phase reference necessary to delay, detect and demodulate. When 6 synchronizing symbols are used, two auxiliary symbols are added to the above symbols.

10   The orthogonal modulation processor 8 will be further described. The D/A converter 81 converts the real part signal R_{sg} and imaginary part signal I_{sg} from digital to analog form. The orthogonal modulator 82 modulates the real part signal on a carrier of

15 frequency F_c from oscillator 83, and modulates the imaginary part signal on a frequency-F_c carrier of which the phase is shifted 90° out of the carrier F_c fed from the oscillator 83, thereby making orthogonal modulation. These modulated signals are combined to produce

20 the OFDM modulated wave signal.

     The operation of the receiving side R_x will be described. In the receiving side R_x, the signal of frames transmitted is supplied to the AGC 9A, where the level of the received signal is changed to a correct

25 level by a control signal S_a internally generated. The OFDM frame signal with its level corrected by the AGC 9A is supplied to the orthogonal demodulation processor 9B.

In this processor 9B, contrary to the transmission side T_x, the orthogonal demodulator 91 demodulates the input signal by applying the carrier signal of frequency F_c' from the voltage controlled oscillator 93, producing the real part signal, and by applying the carrier signal shifted 90°, thus producing the imaginary part signal. These analog real part and imaginary part resulting from the demodulation are converted to digital signals R'_{sg} and I'_{sg} by the A/D converter 92.

The synchronizing detector & correlator 4A searches for breakpoints of frames from the received signals R'_{sg} and I'_{sg}, and produces the frame reference FST_{rc}, and correlation output S_c.

The FFT 3C partitions the symbols on the basis of this pulse FST_{rc}, and performs Fourier transform, thus making OFDM demodulation to produce data R'_f and I'_f.

The decoder 2R discriminates the data R'_f and I'_f by, for example, ROM table, and calculates data D'_0.

The transmission decoder 1R makes reverse interleave processing, energy reverse dispersion processing and error correction processing, thus producing continuous digital data D_{out}, signal S_b indicating BER (Bit Error Rate) status of error corrected situation, and receiving side clock signal CK_{RX}.

Fig. 19 shows one example of the specific

arrangement of the synchronizing detector & correlator
4A. Referring to Fig. 19, the orthogonally demodulated
digital signals, or time base signals R'_{sg} and I'_{sg} are
supplied to NULL end detector 4-1 and SWEEP calculator
5   4-2.

The NULL end detector 4-1 detects the non-
signal state or period, NULL in the synchronizing
symbols from the group of symbols of frames, rough
positions (timing) of the synchronizing symbols, and
10   estimates the SWEEP symbol start points from the NULL
end points by use of a timer circuit, thereby producing
a SWEEP start command pulse ST.

The SWEEP calculator 4-2, while referring to
the SWEEP start command pulse ST, decides the waves
15   existing 2 symbols after the NULL symbol as the SWEEP
symbol wave, receives those, and searches for the
correct switching timing of each symbol.

Specifically, a memory 4-3 in which patterns
of SWEEP symbols are previously stored is used, and the
20   input OFDM signal and the pattern read from the memory
3-4 are processed to undergo, for example, correlation
operation, and to thereby produce the correlation
output S_c, which is then supplied to the FST corrector
4B shown in Fig. 17.

25   The FST corrector 4B calculates a phase shift
from the correct switching timing of each symbol on the
basis of the frame pulse FST_r, and produces the correct
signal VC for the receiving-side reference clock CK_r so

that the frame phase on the receiving side can be coincident with the transmitted data.

Turning back to Fig. 19, a frame counter 4-4 starts counting the clock CK on the basis of the SWEEP

5 start command pulse ST, and produces a pulse FST_r each time the count reaches a value (for example, 1072×900) corresponding to the frame period, in which case the count is reset to 0, and counting of pulse CK is started.

10 Therefore, after that, the pulse FST_r is produced every constant count, or at every frame start point. On the receiving side, this pulse FST_r is used as start timing for fast Fourier transform, decoding and reverse rate conversion.

15 The specific construction of the NULL end detector 4-1 and SWEEP start position estimating process will be described in detail with reference to Figs. 20 and 21.

The signals R'_{sg} and I'_{sg} fed to the NULL end

20 detector 4-1 are converted to their absolute values by absolute value circuits 4-1-1 and 4-1-2, and added together by an adder 4-1-3 to produce an added absolute value 4a.

This added absolute value 4a is compared with

25 a threshold V_{th} in a comparator 4-1-4. Thus, the comparator 4-1-4 produces a compared output 4b that corresponds to the period in which the added absolute value does not exceed the threshold V_{th}, or the NULL

symbol period between T_1 and T_2.

Then, an edge detector 4-1-5 detects the leading edge of the signal, or the compared output 4b to produce a leading edge detected output 4c. A delay
5   circuit 4-1-6 delays this output 4c by one symbol to produce the SWEEP start command pulse ST.

This SWEEP start command pulse ST is able to specify a correct SWEEP symbol start position (T_3). Thus, since the SWEEP calculator 4-2 can receive the
10   SWEEP symbol waves from the start, the phase shift in the SWEEP calculation can be correctly calculated, and the correct switching timing of each symbol can be searched for.

In other words, by detecting the phase shift
15   by the FST corrector 4B on the basis of the correlation output S_c signal produced from the SWEEP calculator 4-2, adjusting the speed of the clock CK_{rc} as the receiving side sample rate, and making synchronizing lock process to the phase of the transmitted synchronizing symbol,
20   it is possible to remove error in the FFT gate timing position. In a case that there is any reflected wave, it is better to place the gate after the symbol period.

Incidentally, if the SWEEP start command pulse is correct in its timing position that is deter-
25   mined on the basis of the detected edge of the synchro- nizing symbol corresponding to rough adjustment, the FFT gate is reduced in its amount of correction for timing position that is made by the speed adjustment of

the clock CK_{rc} corresponding to fine adjustment, and thus the necessary time for the adjustment is also reduced. That is, the gate position can be set with error zero (no error) in a less time, or the best

5 decoding situation can be achieved.

Three examples of the correlation output signal S_c in that case are shown in Figs. 22A, 22B and 22C. From Figs. 22A and 22C, it will be understood that the correlation output signal S_c in that case has

10 no reflected wave and only a sharp peak due to the main wave.

The relation of the synchronizing operation and NULL detecting threshold in the case when there is any reflected wave will be described below.

15 As shown in Fig. 23, when there is any reflected wave, the NULL end point is detected with large error. Thus, since the detected edge position is delayed, the exactness of rough adjustment is reduced, and the amount of correction for fine adjustment

20 increases. Consequently, the necessary time for fine adjustment is increased, and it is delayed to attain the best decoding situation. If the effect of the reflected wave is reduced, selecting the threshold V_{th} to be a lower value will make the NULL end point due to

25 main wave be detected with ease. For example, the lower value of the threshold Vth may be 30 percent of the average power level of the received signal. As a result, the amount of shift at the time of rough

adjustment decreases, so that the necessary time for fine adjustment can be prevented from being extended.

Fig. 24 shows one example of the correlation output signal S_c in such case. From Fig. 24, it will be obvious that the correlation output signal S_c in this case has a peak due to main wave and another peak due to a reflected wave.

The above descriptions were made under the assumption of high CN (carrier to noise ratio) that means the mixture of small noise component. However, as shown in Fig. 25, under a low input electric field intensity, the noise component increases, and a false signal is generated due to the noise component in the NULL period and mixed in the compared result output 4b. Therefore, the exactness of the rough adjustment may be greatly reduced. In addition, when the electric field intensity is further decreased, the noise component in the NULL period always exceeds the threshold V_{th}, making it impossible at all to detect the NULL period end point. In order to assure the operation at low CN, you should increase the threshold V_{th} to a high value. For example, the high value of the threshold Vth may be 80 percent of the average power level of the received signal.

Fig. 26 shows one example of the correlation output signal S_c in such case. From Fig. 26, it will be apparent that the correlation output signal S_c in this case includes a gentle peak due to main wave because

much noise is contained in the SWEEP signal received on
the basis of the FST_r pulse reproduced on the receiving
side and because the degree of coincidence is not
increased at higher CN as compared with that at low CN
5   even though it is calculated while the phase in the
SWEEP pattern memory 4-3 is being shifted.

While an example of the multi-carrier OFDM
modulation has been described so far, a digital trans-
mission system of 64 QAM using a single carrier has the
10   same problem. JP-A-9-247128 discloses a digital signal
receiver in which information of multi-path is repro-
duced from the received signal and displayed together
with the received signal level on the display.
However, this Japanese document teaches that the
15   display merely displays the number of multi-paths and
delay time of the reflected wave as the information
about the multi-path (a state of reflected wave). It
is difficult to check the actual quality of the digital
transmission path of OFDM signal only from such
20   insufficient information. As the result, a good
quality of the reproduced image is not always obtained
by OFDM modulation.

SUMMARY OF THE INVENTION

When such a digital transmission system as
25   described above is used for radio transmission while
being carried on a relay mobile, or outside broadcast
van 51 (52) for marathon as shown in Fig. 53, a

receiving antenna 50 of the receiving station or relay station is required to be always directed toward the transmission antenna of the moving van by direction adjustment so that strong radio waves can be received

5 from the transmission antenna. This direction adjusting operation for the receiving antenna will hereinafter be simply called alignment.

To make the alignment easy, the conventional system shown in Fig. 17 is equipped with means for

10 generating a low frequency signal in response to the electric filed strength (S_a value) that is represented by the control signal S_a in the AGC 9A (for example, means for generating sound of tone interval proportional to the electric field strength though not

15 shown), and with a field strength level meter.

In the conventional analog signal transmission, the transmitted picture quality generally becomes better as the field strength is increased, and thus the operator only adjusts the antenna direction in

20 order that the level meter can indicate the maximum value. In the digital transmission, however, the situation of relatively weak electric field strength, and no reflected wave, or presence of only the main wave will overwhelmingly often provide satisfactory

25 transmission condition as compared with the condition of high electric field intensity and much reflected wave mixed.

Fig. 54 shows one example of the relation

among the electric field strength, error rate and
reflected wave in the OFDM signal transmission. In
this example, it is assumed that the guard interval
period of OFDM signal is selected to be 3 μs, and that
5   a constant level reflected wave is mixed in the
received signal. The abscissa, delay in Fig. 54 is
delay time between main wave and reflected wave. If
the error rate as one of the evaluation parameter of
signal transmission quality is 1.00E-02 or below, a
10   video signal of moving pictures with allowable quality
can be transmitted. As the error rate increases (in
the upward direction along the ordinate of the graph of
Fig. 54), the signal transmission quality becomes poor.
From Fig. 54, it will be understood that the signal
15   transmission quality is, though affected by the
electric field level, or the CN or noise of the
received signal, most affected by the reflected wave
(delayed wave). As illustrated in Fig. 54, when the
filed strength is reduced to -70 dBm or below, the
20   noise component is gradually increased, or the error
rate is deteriorated so that the error mixture rate in
the signal is increased. In addition, when the delay
time of reflected wave exceeds the guard interval, or 3
μs, the error rate greatly increases. In Fig. 54,
25   although the reflected wave level is assumed to be
constant, the increase of the reflected wave level will
increase the error rate. Therefore, even if the filed
strength is slightly lowered, the receiving antenna

should be adjusted in its orientation so that the
reflected wave can be decreased or that the delay time
of reflected wave is confined within 3 μs.

Thus, it is difficult to achieve the best

5   receiving condition in digital transmission by adjust-
ing the antenna orientation while monitoring only the
field intensity as in the prior art. It is necessary
to adjust the antenna by considering the reflected wave
in addition to the field strength.

10   The present invention is to propose a system
and method capable of offering the operator the means
to display images by correctly imaging the signal
transmission status information that indicates at least
the condition of reflected waves in order to achieve

15 the best receiving condition on the receiving side when
a digital signal is transmitted.

Since the conventional analog transmission
system is greatly affected by reflected waves, it is
used only under the condition that the transmitting

20 side and receiving side are placed under an
unobstructed view. The recently developed digital
transmission system of particularly OFDM modulation
system has less effect of reflected waves, and thus can
be positively used for beyond-the-horizon transmission

25 as described above.

However, for beyond-the-horizon transmission,
the antenna orientation adjustment operator cannot view
the transmitting side. Therefore, in order for the

operator to make correct alignment relative to the transmitting side that cannot be viewed, the operator needs to detect the field strength and BER (Bit Error Rate), display them on an exclusive level meter or the

5 like, and compare those with the reproduced picture.

Here, in order to image the received signal in the digital transmission system, it is necessary that the digital data D_{out} obtained by OFDM demodulation in the above-mentioned receiving side processor 203 be

10 decoded by use of an MPEG decoder not shown. Thus, in the digital transmission system, since it is not easy to image the received signal on the receiving antenna side on which the antenna adjustment operator engages in the adjustment, the alignment is often performed by

15 use of the aforementioned exclusive field intensity or BER level meter.

However, since such situation as somewhat weak field strength and no reflected wave, or presence of only main wave in the digital transmission over-

20 whelmingly often provides good transmission condition as compared with the situation of strong field and presence of much mixed reflected wave as described above, only comparing the field strength and BER with the reproduced picture for the purpose of alignment

25 without grasping the situation in which the reflected waves are mixed (ghost-status) does not always lead to high quality transmission.

The present invention is to remove these

defects, and make it easy to maintain high quality digital transmission by imaging the presence or absence of reflected waves and the mixed state of reflected waves (ghost-status), imaging the field strength and

5 BER value, and observing these situations comprehensively for the alignment because the transmission quality cannot always be perceived by measuring only the field intensity and BER in the digital transmission of OFDM signal or the like.

10   It is another object of the invention to display the imaged transmission-condition in synchronism with other imaging signals, or in the so-called superimposed state in order that the operator can make antenna alignment with a plurality of outside

15 broadcast vans without watching a large number of monitors.

      It is still another object of the invention to superimpose, when an abnormal transmission-condition is detected, the imaged abnormal transmission-condition

20 waveform on the normal transmission-condition waveform, and residually display those images for a predetermined time, thus making it possible to grasp the transmission path characteristics.

      Moreover, it is an object of the invention to

25 generate alarm sound when the abnormal state occurs in order to inform the operator of the abnormal state occurrence.

      In addition, as shown in Fig. 53, a relay

point 53 is provided on a hill or the hights in the
general mobile relay, and digital imaging signals are
transmitted from the outside broadcast vans 51, 52 to
the relay point 53 by use of the aforementioned OFDM

5   transmission system. The imaging signals received by
the relay apparatus 53 provided on the hill are
transmitted to a broadcast station 54 having studios
via a microwave channel 55 of analog transmission
system.

10   A responsible person (a director) in this
transmission system generally works on the studio side
at the final receiving stage. He commands all the
transmission relay operations and orders workers at
each place of duty. For example, he orders to select

15   and decide any ones to go on the air, from the images
that have been transmitted from a plurality of vans 51,
52.

     In this case, although the mobile relay
transmission-condition in the digital transmission

20   system ever changes every second as described above,
even seeing only the video images transmitted without
grasping the electric field intensity, BER and the
mixed state of reflected waves (ghost-status) cannot
lead to correct decision of whether the transmission-

25   condition is good. The reason for this is that in the
digital transmission system the video images trans-
mitted can be satisfactorily reproduced until the
limited poor transmission conditions in which the

demodulation can be barely performed occur, and when the demodulation cannot be made, an abnormal phenomenon such as freeze of a reproduced picture on a display is suddenly caused.

5   Therefore, the director on the studio side cannot select appropriate on-air images from the video images transmitted from a plurality of outside broadcast vans because the transmission-condition of each van, or the field strength, BER and the mixed state of

10   reflected waves (ghost-status) are uncertain. Thus, the selected on-air video images are sometimes suddenly frozen by a poor transmission-condition, leading to broadcasting accident.

The present invention is to remove these

15   defects, and make it possible for the director to correctly grasp the transmission-conditions by transmitting information of the field strength, BER, and the mixed state of reflected waves (ghost-status) that indicate the transmission-conditions of these mobile

20   relaying bodies from the OFDM transmission system to a remote studio located distant therefrom, and by displaying those images.

According to one aspect of the invention, there is provided a digital signal transmission system

25   using a digital modulation system comprising a digital signal transmitter having a first digital signal processing unit and a digital signal receiver receiving a digital signal from the transmitter. The digital

signal receiver comprises a second digital signal
processing unit for processing the digital signal from
the transmitter and outputting a digital demodulated
signal and a correlation value signal, a signal

5   converter coupled with the second digital signal
processing unit and supplied the correlation value
signal therefrom for generating a waveform indicating a
transmission condition including a main wave in
response to the correlation value signal, and a display

10   coupled with the signal converter for displaying the
waveform indicating a transmission condition in the
digital transmission system.

        According to another aspect of the invention,
there is provided a digital signal receiver to which a

15   digital signal from a digital signal transmitter using
a digital modulation system is supplied. The digital
receiver comprises a second digital signal processing
unit for processing the digital signal and outputting a
digital demodulated signal and a correlation value

20   signal, a signal converter coupled with the second
digital signal processing unit and supplied said
correlation value signal therefrom for generating a
waveform indicating a transmission condition including
a main wave and a reflected wave in response to the

25   correlation value signal, and a display coupled with
the signal converter for digital signal.

        According to still another aspect of the
invention, there is provided a method of displaying a

digital signal transmission condition in a digital

signal receiver. A digital signal is transmitted to

the receiver from a digital signal transmitter using a

digital modulation system. The method comprises the

5 steps of processing the digital signal in a second

digital signal processing unit of the digital signal

receiver, outputting a digital demodulated signal and a

correlation value signal from the second digital signal

processing unit, generating a waveform indicating a

10 transmission condition including a main wave in

response to the correlation value signal in a signal

converter coupled with the second digital signal

processing unit, and displaying the waveform indicating

a transmission condition of the digital signal on a

15 display.

According to further aspect of the invention,

there is provided a digital signal transmission system

by which a video signal modulated by a digital modula-

tion system is transmitted via at least one relay

20 apparatus to another receiver. In this digital signal

transmission system, the relay apparatus has a trans-

mission condition signal generator for generating a

ghost-status signal that indicates the mixed state of

reflected waves in the received video signal, a signal

25 converter for converting the ghost-status signal into a

ghost-status imaging signal so that the ghost-status

signal can be imaged on a display, and a transmitter

for transmitting the ghost-status imaging signal and

the video signal to the receiver. The receiver has
circuit means for extracting the ghost-status imaging
signal from the received signal.

According to the invention, when at least
5 ghost-status imaging signal or additionally the BER
imaging signal and field intensity imaging signal are
displayed together on a video monitor, the trans-
mission-conditions based on those imaging signals can
be comprehensively viewed in association with each
10 other, and thus be correctly grasped. Therefore, the
antenna alignment operator can work for alignment
effectively by viewing these images.

Moreover, according to the invention, the
information of field strength, BER, and mixed state of
15 reflected waves (ghost-status) that indicate the
conditions of the signal transmission from the mobile
relaying stations is transmitted from the OFDM
transmission system to a remote place, or a studio as
the final receiving stage, where the transmission-
20 conditions can be displayed, and thus the director or
other persons can correctly grasp the transmission-
conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the whole
25 construction of one embodiment of a digital trans-
mission system according to the invention.

Fig. 2A is a block diagram of one example of

the transmission-condition-to-image converter 7 according to the invention.

Fig. 2B is a schematic diagram showing one example of the displayed state of each transmission
5 condition imaging signal on a display screen.

Fig. 3A is a block diagram of one example of the field-intensity-to-image converter 7-1 according to the invention.

Fig. 3B is a schematic diagram showing one
10 example of the displayed state of the field strength imaging signal on a display screen.

Fig. 4A is a block diagram of one example of the BER-to-image converter 7-2.

Fig. 4B is a schematic diagram showing one
15 example of the displayed state of the BER imaging signal on a display screen.

Fig. 5 is a block diagram showing the construction of one embodiment of the ghost-status-to-image converter 7-3 according to the invention.

20 Fig. 6 is a timing chart showing waveforms in the ghost-status-to-image converter 7-3 according to the invention.

Fig. 7 is a schematic diagram showing one example of the displayed state of the ghost-status
25 imaging signal according to the invention.

Fig. 8 is a block diagram showing the construction of one embodiment of the image integrator 7-4 according to the invention.

Fig. 9A is a schematic diagram showing one example of the displayed state of the time scale and guard interval of the ghost-status imaging signal.

Fig. 9B is a timing chart of the signal

5   occurrence of synchronizing signal, scale signal and interval signal.

Figs. 10A through 10E are schematic diagrams showing examples of the transmission-conditions displayed according to the invention.

10   Fig. 11 is a block diagram showing the construction of one embodiment of a transmission-condition image superimposing device 7b according to the invention.

Fig. 12 is a block diagram showing the

15   construction of one embodiment of the image integrator 7b-4 according to the invention.

Fig. 13 is a block diagram showing the construction of one embodiment of the synchronizing signal generator 7b-4-5 according to the invention.

20   Fig. 14 is a block diagram showing the construction of one embodiment of the BER-to-image converter 7b-2 according to the invention.

Fig. 15 is a schematic diagram showing one example of the displayed state of the BER imaging

25   signal according to the invention.

Fig. 16 is a block diagram showing the whole construction of another embodiment of a video/audio transmission system according to the invention.

Fig. 17 is a block diagram showing the whole construction of the general OFDM transmission system.

Fig. 18 is a block diagram showing the construction of the synchronizing symbol inserter 5 of the transmission system of Fig. 17.

Fig. 19 is a block diagram showing the construction of the synchronizing detector & correlator 4A of the transmission system of Fig. 17.

Fig. 20 is a block diagram showing the construction of the NULL end detector 4-1 of the synchronizing detector & correlator 4A of Fig. 19.

Fig. 21 is a timing chart to which reference is made in explaining the operation for the NULL detection and SWEEP start position estimation.

Figs. 22A, 22B and 22C are graphs showing examples of the correlation output signal S_c with no reflected wave.

Fig. 23 is a timing chart to which reference is made in explaining the operation for the NULL detection and SWEEP start position estimation.

Fig. 24 is a graph showing one example of the correlation output signal S_c with reflected waves mixed.

Fig. 25 is a timing chart to which reference is made in explaining the operation for the NULL detection and SWEEP start position estimation.

Fig. 26 is a graph showing one example of the correlation output signal S_c at a low field strength.

Fig. 27 is a block diagram showing one

embodiment of a ghost-status-to-image converter 7a-3
according to the invention.

Fig. 28 is a schematic diagram showing one
example of the displayed state of each transmission-
5   condition imaging signal according to the invention.

Fig. 29 is a timing chart showing waveforms
in the ghost-status-to-image converter 7a-3 of Fig. 27.

Fig. 30 is a block diagram showing one
example of the transmission-condition-to-image
10 converter 7a according to the invention.

Fig. 31 is a schematic diagram showing one
example of the displayed state of each transmission-
condition imaging signal according to the invention.

Fig. 32 is a block diagram showing one
15 example of the abnormal-state detector & residual
display 7a-5 according to the invention.

Fig. 33 is a block diagram showing one
example of the abnormal ghost-status residual display
7a-5B according to the invention.

20   Fig. 34 is a schematic diagram to which
reference is made in explaining the divisional process-
ing of the abnormal state detected screen according to
the invention.

Fig. 35 is a block diagram showing one
25 example of the abnormal state detector 7a-5A of the
abnormal state detector & residual display 7a-5 Fig.
32.

Fig. 36 is a block diagram showing one

example of the abnormality detection signal generator
7a-5A-3 of the detector of the abnormal state detector
7a-5A of Fig. 35.

Fig. 37 is a block diagram showing one
example of the abnormal condition detector 5A-3-3
according to the invention.

Fig. 38 is a block diagram showing one
example of the FIFO write controller 7a-5-13 of the
abnormal ghost-status residual display 7a-5B of Fig.
33.

Fig. 39 is a timing chart showing waveforms
in the abnormal state detector & residual display 7a-5
of Fig. 32.

Fig. 40 is a timing chart showing the
operation of the abnormal state detector 7a-5A of Fig.
35.

Fig. 41 is a block diagram showing one
example of a transmission-condition-to-image converter
7a' according to the invention.

Fig. 42 is a block diagram showing one
example of the ghost-status-to-video state/abnormal-
state detector & residual display 7a-7 according to the
invention.

Fig. 43 is a block diagram showing one
example of a transmission-condition-to-image converter
7c according to the invention.

Figs. 44A and 44B are schematic diagrams
showing examples of the displayed state of each

transmission-condition imaging signal according to the
invention.

Fig. 45 is a block diagram showing one
example of the guard interval mode detector 7c-8 of the
5   converter 7c of Fig. 43.

Figs. 46A and 46B are diagrams to which
reference is made in explaining the guard interval mode
detection operation according to the invention.

Fig. 47 is a block diagram showing one
10   example of the ghost-status-to-image converter 7c-3
according to the invention.

Fig. 48 is a block diagram of the counter 7c-
3-9 of the ghost-status-to-image converter 7c-3 of Fig.
47.

15   Figs. 49A and 49B are waveform diagrams to
which reference is made in explaining the operation of
the counter 7c-3-9 of Fig. 48.

Fig. 50 is a block diagram showing one
example of the image integrator 7c-4 according to the
20   invention.

Fig. 51 is a block diagram showing one
example of the external video synchronizing type
synchronizing signal generator 7c-4-5 according to the
invention.

25   Figs. 52A and 52B are schematic diagrams to
which reference is made in explaining the displayed
states of the guard interval range.

Fig. 53 is a schematic diagram showing an

example of the operation of the digital transmission system.

Fig. 54 is a diagram showing the relation among the field intensity, error rate and delay time between main wave and reflected wave.

Fig. 55 is a block diagram of the whole construction of another embodiment of a transmission system according to the invention.

Figs. 56A, 56B and 56C are schematic diagrams showing the relations between transmission signal waveforms and displayed screens according to the invention.

Fig. 57 is a block diagram of one embodiment of the image integrator 7-4 according to the invention.

Fig. 58 is a schematic diagram showing a transmission-condition superimposed video signal waveform according to the invention.

Fig. 59A is a block diagram of the field-intensity-to-image converter 7-1 according to the invention.

Fig. 59B is a schematic diagram showing one example of the displayed picture.

Fig. 60A is a block diagram of the BER-to-image converter 7-2 according to the invention.

Fig. 60B is a schematic diagram showing one example of the displayed picture.

Fig. 61 is a block diagram showing the construction of the ghost-status-to-image converter 7-3 according to the invention.

Fig. 62 is a timing chart of the signal at each part of the ghost-status-to-image converter 7-3 according to the invention.

Fig. 63A is a block diagram of a superimposed information extractor & transmission-condition-to-image converter 7R according to the invention.

Fig. 63B is a schematic diagram showing one example of the displayed picture.

Fig. 64A is a block diagram of a superimposed field intensity extractor & field-intensity-to-image converter 7-1V according to the invention.

Fig. 64B is a schematic diagram of one example of the displayed picture.

Fig. 65A is a block diagram of a superimposed BER extractor & BER-to-image converter 7-2V according to the invention.

Fig. 65B is a schematic diagram showing one example of the displayed picture.

Fig. 66A is a block diagram of a superimposed ghost-status extractor & ghost-to-image converter 7-3V according to the invention.

Fig. 66B is a schematic diagram showing one example of the displayed picture.

Fig. 67 is a timing chart to which reference is made in explaining the operation of the superimposed ghost-status extractor & ghost-to-image converter 7-3V of Fig. 66A.

Fig. 68 is a block diagram showing the

construction of one example of a transmission-condition
image superimposing device and transmission-condition
adder according to the invention.

Fig. 69 is a schematic diagram showing one
5   example of a transmission-condition superimposed
imaging signal waveform according to the invention.

Fig. 70A is a block diagram of a field-
intensity-to-level converter 7-6 according to the
invention.

10   Fig. 70B is a schematic diagram showing one
example of the displayed picture.

Fig. 71A is a block diagram of a BER-to-level
converter 7-7 according to the invention.

Fig. 71B is a schematic diagram showing one
15   example of the displayed picture.

Fig. 72A is a block diagram of a time-to-BER
converter 7-2Vr according to the invention.

Fig. 72B is a timing chart of signals in the
time-to-BER converter 7-2Vr.

20   Fig. 73 is a block diagram showing the whole
construction of a single-carrier system transmission
system of still another embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

Fig. 1 shows the whole construction of an
25   OFDM modulation type transmission system according to
the invention. The construction and operation of
chiefly the receiving side will be described.

This transmission system has the trans-
mission-side processor 101 on the transmitting side Tx
as shown in detail in Fig. 17, the receiving-side
processor 203 on the receiving side Rx as shown in

5   detail in Fig. 17, a transmission-condition-to-image
converter 7, and a video display 11 as shown in Fig. 1.

Referring to Fig. 1, on the receiving side
Rx, the AGC control signal Sa indicating an electric
field intensity that is produced from the receiving-

10   side processor 203, the correlation output Sc such as a
correlation value signal and the signal Sb indicating
BER are supplied to the transmission-condition-to-image
converter 7. Also, the pulse FSTrc as the operation
timing reference from the receiving-side processor 203

15   is supplied to the transmission-condition-to-image
converter 7. The transmission-condition imaging signal
thus generated from the converter 7 is displayed on the
video display 11.

Fig. 2A is a block diagram of one embodiment

20   of the transmission-condition-to-image converter 7.
With reference to Fig. 2A, this converter will be
described.

The control signal Sa is supplied to the
input end of the field-intensity-to-image converter 7-

25   1. The output from the field-intensity-to-image
converter 7-1 is fed to the input end of the image
integrator 7-4.

The signal Sb is supplied to the input end of

the BER-to-image converter 7-2. The output from the
BER-to-image converter 7-2 is fed to the image
integrator 7-4.

The signal Sc and signal FSTrc are supplied
5 to the input ends of the ghost-status-to-image
converter 7-3. The output from the ghost-status-to-
image converter 7-3 is fed to the image integrator 7-4.

The synchronizing signal C.Sync from the
image integrator 7-4 is supplied to the synchronizing
10 input ends of the field-intensity-to-image converter 7-
1, BER-to-image converter 7-2 and ghost-status-to-image
converter 7-3. The image integrator 7-4 produces a
transmission-condition imaging signal which will be
described later.

15 The field-intensity-to-image converter 7-1,
BER-to-image converter 7-2 and ghost-status-to-image
converter 7-3 are responsive to the synchronizing
signal C.Sync to convert their input condition, or
status signals to imaging signals. The image
20 integrator 7-4 combines these imaging signals to form a
transmission-condition imaging signal with a video
synchronizing signal added.

Fig. 2B shows one example of the displayed
picture, or screen of each transmission-condition
25 imaging signal. This example will be described below.

The ghost-status image is displayed as a
correlation output waveform of a bar graph or
sequential line graph with a time scale and guard

interval range added on the left side of the screen.
Here, a high peak due to main wave and a low peak due
to reflected wave are shown. The BER image is
displayed as dot blocks of intermediate size on the
5 upper right side of the screen. The field strength
image is displayed as a few columns of stacked small
blocks arranged on the lower right side of the screen.
These waveforms and block number are changed in
accordance with the transmission conditions. These
10 transmission condition images are updated depending on
the renewal period of the imaging signals received and
decoded.

Fig. 3A is a block diagram of one embodiment
of the field-intensity-to-image converter 7-1. Fig. 3B
15 is a schematic diagram showing the displayed state of
the field-strength image. This converter will be
described with reference to those figures.

The control signal Sa indicative of a field
strength is supplied to and converted by an A/D
20 converter 7-1-1 into a digital signal DSa of, for
example, 6 bits. The signal DSa indicative of a field
strength is changed to, for example, a 24-bit binary
signal of Da0~Da23 by a decoder (DEC) 7-1-2. Here, if
signal DSa is 01h, or 1 in decimal notation, only Da0
25 and Da1 become level "High". If signal DSa is 15h, or
21 in decimal notation, Da0 through Da21 become level
"High".

These bits Da0 through Da23 are respectively

supplied to 24 AND gates (AND) 7-1-4. The 24 outputs
from the AND 7-1-4 are supplied to an OR gate (OR) 7-1-
5. The synchronizing signal C.Sync is supplied to a
display position pulse generator 7-1-3, which then
5 generates display position pulses a0 through a23 in
synchronism with the synchronizing signal C.Sync.
These pulses a0 through a23 are supplied to the other
input ends of the AND 7-1-4, which then computes the
logical products of these pulses and signals Da0
10 through Da23, respectively.

Here, if the signal DSa indicative of a field
strength is 00h, or zero in decimal notation, only the
signal Da0 becomes level "High". Thus, only the
logical product of pulse a0 and signal Da0 is "High",
15 only the block at the position corresponding to pulse
a0 is displayed. If signal DSa is 16h, or 22 in
decimal notation, the products of signals Da0 through
Da22 and pulses a0 through a22 are "High". Thus, all
the blocks at the positions corresponding to pulses a0
20 through a22 are displayed.

Here, if it is assumed that the pulse a0
becomes level "High" at the position of scanning lines
208-th H (Horizontal line) through 210-th H, and sample
numbers 384-th through 414-th sample, the pulse a22 is
25 level "High" at the position of scanning lines 202-th H
through 204-th H, and sample numbers 540-th through
570-th sample, and pulse a23 is level "High" at the
position of scanning lines 199-th H through 201-st H,

and sample numbers 540-th through 570-th sample, then the field strength image will be displayed as shown in Fig. 3B.

In other words, the number of blocks corresponding to the field strength image is changed in accordance with the value of the control signal Sa indicative of a field strength.

Fig. 4A is a block diagram of one embodiment of the BER-to-image converter 7-2. Fig. 4B is a schematic diagram showing the displayed state of the BER condition imaging signal on the display. This converter will be described.

The signal Sb indicative of a BER condition is supplied to and converted by an A/D converter 7-2-1 into a digital signal DSb of about 3 bits. The signal DSb indicative of the BER condition is converted by a decoder (DEC) 7-2-2 to, for example, all five signals of Db0 through Db4.

Here, if the signal DSb is 01h, or one in decimal notation, only signals Db1 and Db0 become level "High". The outputs of Db0 through Db4 are supplied to five AND gates (AND) 7-2-4. The five outputs from the AND 7-2-4 are supplied to an OR gate (OR) 7-2-5.

The synchronizing signal C.Sync is supplied to a display position pulse generator 7-2-3, which then produces pulses b0 through b4 for the BER condition in synchronism with the synchronizing signal C.Sync. The pulses b0 through b4 for the BER condition are

displayed on the display as shown in Fig. 4B.

The pulses b0 through b4 are supplied to the other input terminals of the AND 7-2-4, which compute the logical products of those pulses and the signals

5   Db0 through Db4, respectively. Here, if the signal DSb indicative of BER is 00h, or 0 in decimal notation, only the signal Db0 is level "High". Thus, the product of the pulse b0 and signal Db0 becomes level "High", and only the block at the position corresponding to

10   pulse b0 is displayed. If the signal DSb is 03h, or 3 in decimal notation, the logical products of signals Db0 through Db3 and pulses b0 through b3 are level "High". Thus, all blocks at the positions correspond- ing to pulses b0 through b3 are displayed.

15   In other words, the block number of the BER image is changed depending on the value of the control signal Sb indicative of the BER condition.

A description will be made of the logical processing for displaying the BER condition displaying

20   pulses b0 through b4 on the display as shown in Fig. 4B.

The display position pulse generator 7-2-3, if it is used for NTSC, makes logical operation using a 1/910 frequency dividing counter that counts at a clock of 14.3 MHz and is reset with a horizontal scanning

25   period and a 1/525 frequency dividing counter that counts at a clock of a half horizontal scanning period and is reset with a vertical scanning period.

Thus, as shown in Fig. 4B, the b4 pulse, for instance, is displayed at the position of scanning lines of 80-th H through 96-th H, and sample number of 512-nd through 526-th sample, and the b3 pulse at the

5 position of scanning lines of 80-th H through 96-th H, and sample number of 528-th through 542-nd sample. The b2 pulse is displayed at the position of scanning lines of 80-th H through 96-th H, and sample number of 544-th through 558-th sample. The b1 pulse is displayed at

10 the position of scanning lines of 80-th H through 96-th H, and sample number of 560-th through 574-th sample. The b0 pulse is displayed at the position of scanning lines of 80-th H through 96-th H, and sample number of 576-th through 590-th sample.

15 Fig. 5 is a block diagram of one embodiment of the ghost-status-to-image converter 7-3. This example will be described.

The correlation output signal Sc indicative of the ghost-status is supplied to and converted by an

20 A/D converter 7-3-1 to a digital correlation output signal DSc of 8 bits. This signal DSc is supplied to an input of a FIFO 7-3-2. The pulse FSTrc with frame period is supplied to the write-in reset terminal of the FIFO 7-3-2. The digital correlation output signal

25 D'Sc from the FIFO 7-3-2 is supplied to a comparator 7-3-4. The output from the comparator 7-3-4, or a ghost level signal LE is supplied to a gate 7-3-6. The synchronizing signal C.Sync is supplied to a timing

pulse generator 7-3-3. The generator 7-3-3 is respon-
sive to the synchronizing signal C.Sync to supply a
read reset signal RRST and read enable signal RE to the
FIFO 7-3-2, a synchronizing signal HD to an H-counter

5   7-3-5, and a blanking gate signal BG to the gate 7-3-6.
The H-counter 7-3-5 generates a triangular-wave signal
Dh of H (Horizontal scanning) period in response to the
signal HD, and supplies it to the comparator 7-3-4.

        Fig. 6 is a timing chart showing the relation

10   among the signals C.Sync, RRST, RE, HD, Dh, BG and LE.
The operation of this converter will be described with
reference to Figs. 5 and 6.

        The timing pulse generator 7-3-3 generates
the reset signal RRST at the start of each video field

15   period, and forces the FIFO (first-in first-out memory)
7-3-2 to make it ready to read from the first written-
in content. In addition, it generates the RE signal at
each H period, and orders the FIFO 7-3-2 to sequen-
tially read the written-in contents (DSc) one by one.

20   The signal D'Sc read at each video H-period is supplied
to the comparator 7-3-4 where it is compared with the
value Dh of each H-period. Thus, the comparator
produces the ghost level signal LE that becomes level
"High" when D'Sc is larger than Dh, or D'Sc > Dh.

25   Here, in order to prevent the signal LE from being
generated in the blanking periods, the signal BG that
becomes level "Low" in the blanking periods is
generated, making the ghost level signal LE forcibly

level "Low".

        Therefore, if the correlation output signal

Sc has high level, the gate 7-3-6 produces the signal

LE of a long High-level period as the ghost-status

5   imaging signal, or ghost imaging signal.

        A description will be made of the case in

which the ghost imaging signal is displayed by a bar

graph on the left side of the display screen in the

vertical direction along the time base as shown in Fig.

10 7. Here, it is assumed that the ghost level signal LE

corresponding to the n-th scanning line is the main

wave, and takes the maximum. It is also assumed thaat

the signal Dh is incremented by one at each two

samples, and finally reaches about 450.

15   If the signal D'Sc corresponding to the n-th

scanning line is a value of 241, the time at which the

value of Dh from the H-counter 7-3-5 exceeds 241 is at

the 482-nd sample, and thus the ghost level signal LE

will be level "High" during the time interval of the

20 first sample through 482-nd sample. However, since the

signal BG is L level during the interval from the first

sample to 90-th sample, the signal LE gated is level

"Low" when the signal BG is level "Low". Thus, the

ghost imaging signal corresponding to the n-th scanning

25 line become level "High" during the interval from 91-st

sample to 482-nd sample, with the result that the LE of

the n-th scanning line can be displayed as shown in

Fig. 7.

If the signal D'Sc corresponding to the (n+1)-th scanning line is a value of 123, the time at which the value of Dh exceeds 123 is at the 246-th sample. The LE will be level "High" during the

5 interval from the first sample to the 246-th sample. However, since the signal BG of L level is supplied to the gate as mentioned above, the ghost imaging signal corresponding to the (n+1)-th scanning line becomes level "High" during the interval from the 91-st to the

10 246-th sample, so that the LE of the (n+1)-th scanning line is displayed as shown in Fig. 7.

Similarly, if the signal D'Sc corresponding to the (n-2)-th scanning line is a value of 89, the time at which the value of Dh exceeds 89 is at the 178-

15 th sample, and thus the ghost level signal LE will be level "High" during the interval from the first sample to the 178-th sample. However, since the signal BG of L level is supplied to the gate as above, the ghost imaging signal of the (n-2)-th scanning line becomes

20 level "High" during the interval from the 91-st to 178-th sample, and thus displayed as shown in Fig. 7.

Fig. 8 is a block diagram of one embodiment of the image integrator 7-4. This integrator will be described.

25 The field-intensity imaging signal, BER imaging signal and ghost imaging signal are supplied to an adder 7-4-6 via gates 7-4-1, 7-4-2, 7-4-3, respectively.

A display selector 7-4-4 generates signals
for individually selecting (ON/OFF) one being
displayed, of the field-intensity imaging signal, BER
imaging signal and ghost imaging signal. A video

5 synchronizing signal generator 7-4-5 supplies the
synchronizing signal C.Sync to the adder 7-4-6 and the
outside, and a pulse indicative of the time base scale
and guard interval for the ghost imaging signal to the
adder 7-4-6. If the video synchronizing signal

10 generator 7-4-5 is used for NTSC, it makes logic
processing by use of a 1/910 frequency dividing counter
that counts at a clock of 14.3 MHz and is reset with H-
period, and by a 1/525 frequency dividing counter that
counts at a clock of 1/2 H (Horizontal period) and is

15 reset with V (Vertical)-period. The gates 7-4-1, 7-4-
2, 7-4-3 respectively respond to the signals from the
display selector 7-4-4 to allow the field-intensity
imaging signal, BER imaging signal and ghost imaging
signal to pass therethrough or not. The adder 7-4-6

20 adds each imaging signal that has passed through the
gate 7-4-1, 7-4-2, 7-4-3, and the signal indicative of
the scale and interval in synchronism with the
synchronizing signal C.Sync to produce a transmission-
condition imaging signal in order that each imaging

25 signal can be displayed as blocks, dots or bar graph of
a certain size on the display screen at a predetermined
position.

One example of the rates of the imaging

signals to be added in the adder 7-4-6 will be given

below. If all signals fed to the adder 7-4-6 have +5 V

in digital level, the rates of the field-intensity

imaging signal, BER imaging signal and ghost imaging

5   signal are 0.2, the rates of the scale signal and

interval signal are 0.05, and the rate of the synchro-

nizing signal C.Sync is 0.1. Thus, the transmission-

condition imaging signal generated has about 1 Volt$_{p-p}$

including the synchronizing signal.

10   Fig. 9A is a schematic diagram showing a

signal cur of time base scale and a signal C-GI of

guard interval for the ghost imaging signal on the

monitor screen. Fig. 9B is a timing chart showing the

generation of the scale signal cur and interval signal

15   C-GI with respect to the synchronizing signal C.Sync.

It is assumed that the time scale signal cur

becomes level "High" at intervals of 16 Hs in the range

from the 32-nd H to the 240-th H and at lateral

positions from the 108-th to 144-th sample within the

20   effective range of the monitor. It is also assumed

that the interval signal C-GI becomes level "High" at

scanning lines from the 112-nd H to 160-th H, and in

the sample range from the 112-nd to 128-th sample.

The signal C-GI indicative of the guard

25   interval, when the transmission condition is normal, is

set to start being displayed from the n-th scanning

line at which the main wave should exist, and to end 48

Hs after when the guard interval is 3 μ sec and the

sampling clock frequency for OFDM is 16 MHz. Thus, it becomes a band shape image indicating 3 μ sec. The signal cur indicative of the time scale, if the sample clock frequency for OFDM is 16 MHz, provides a scale at

5 intervals of 1 μ sec by setting it to be level "High" at intervals of 16 Hs.

Figs. 10A to 10E are schematic diagrams showing different transmission-condition displaying screens. With reference to these figures, a descrip-

10 tion will be made of the situation in which the operator can correctly grasp the present transmission-condition by displaying the ghost imaging signal, BER imaging signal and field intensity imaging signal on the monitor.

15 Fig. 10A shows one example of the ghost image displayed when the main wave of high level with no reflected wave is received. In this case, a high-level peak indicating the main wave is present at around the n-th scanning line within a guard interval of 2 μ sec

20 indicated by a dotted line. In addition, the BER condition displayed on the upper right side and the field intensity displayed on the lower right side are satisfactory values. Thus, it will be seen that this screen shows a very good transmission-condition.

25 Fig. 10B shows one example of the ghost image displayed when the main wave of high level is received and a reflected wave of intermediate level is received within the guard interval (2 μ sec) after the reception

of the main wave. In this case, the high-level main
wave exists at around the n-th scanning line within the
guard interval, and the second peak of intermediate
level is displayed at about 2/3 of the guard interval.

5   From this screen, it will be understood that the
reflected wave of intermediate level exists as the
second peak and is within a delay time of about 2 μ
sec, or within the guard interval so as to be
neglected. In addition, the BER condition and field

10 strength are relatively good. Consequently, this
screen shows a satisfactory transmission-condition.

       Fig. 10C shows one example of the ghost image
displayed when the main wave of high level is received
and a reflected wave of low level is received 5 μ sec

15 after the reception of the main wave, or beyond the
guard interval. In this case, a high peak of the high-
level main wave exists at around the n-th scanning line
within the guard interval, and a second low peak
appears beyond the guard interval. From this figure,

20 it will be understood that, since a reflected wave of a
low level peak occurs about 5 μ sec after the main
wave, or beyond the guard interval, the effect of the
reflected wave cannot be compensated by the guard
interval. In addition, the field intensity is good,

25 but the BER is somewhat poor. Thus, this screen shows
a slightly unsatisfactory transmission condition. In
this case, the operator might adjust the antenna
orientation so that the delay time of the reflected

wave can be confined within the guard interval.

Fig. 10D shows one example of the ghost image displayed when the main wave of intermediate level is received, and when a reflected wave of high level

5 occurs 5 μ sec after the reception of the main wave, or beyond the guard interval. In this case, a peak of the main wave exists at around the n-th scanning line within the guard interval, and the second peak of high level appears out of the guard interval. From this

10 figure, it will be understood that since the reflected wave of larger level than the main wave occurs about 5 μ sec after the main wave, or beyond the guard interval, the reflected wave of high level cannot be neglected. In addition, the BER, and field intensity

15 are both poor. Thus, this screen shows an unsatis- factory transmission-condition. In this case, the operator would need to adjust the antenna orientation so that the level of the main wave in the received siganl can be increased.

20 Fig. 10E shows one example of the ghost image displayed when the main wave of low level is received, and when a reflected wave of high level arrives as short as 2 μ sec after the reception of the main wave.

In this case, a low peak of the main wave

25 exists before the n-th scanning line, and a second high peak appears at around the n-th scanning line within the guard interval. From the figure, it will be seen that not the main wave of the first low peak but the

reflected wave of the second high peak is about to be received and synchronized with. In addition, the field intensity is satisfactory, but the BER is poor. Thus, this screen shows a considerably unsatisfactory

5 transmission-condition.

Since this reflected wave of high level is normally not kept high level, but will disappear before long, it is highly likely that phase shifting of clock occurs to switch the synchronized reception back to the

10 main wave when the reflected wave level is reduced. In this case, there is the possibility that the BER value becomes very poor, and it can be predicted that a very poor transmission-condition occurs in a short time. Therefore, this received signal might not be used for

15 video broadcasting. A signal received from other outside broadcast vans might be used.

Thus, by displaying the ghost imaging signal, BER imaging signal and field intensity imaging signal on the monitor display, it is possible to correctly

20 grasp the transmission-condition because the conditions of these imaging signals can be comprehensively observed in association with each other.

Therefore, the operator to adjust the antenna orientation is able to effectively make alignment

25 operation while viewing these displayed images.

Fig. 11 is a block diagram of one embodiment of the transmission-condition image superimposing device 7b for superimposing the transmission-condition

imaging signals and the received and decoded video signal. This superimposing device 7b can replace the transmission-condition-to-image converter 7 shown in Fig. 1. This superimposing device 7b will be described

5   below.

The digital data D_{out} produced from the receiving-side processor 203 of Fig. 1 by OFDM demodulation is decoded by an MPEG decoder not shown into the video signal, which is then supplied to the

10   image integrator 7b-4. The control signal Sa indicative of a field intensity, the signal Sb indicative of BER, and the correlation output signal Sc are supplied to a field-intensity-to-image converter 7b-1, a BER-to-image converter 7b-2 and a ghost-to-image converter 7b-

15   3, respectively. The imaging signals from those converters are supplied to the image integrator 7b-4.

Fig. 12 is a block diagram of this image integrator 7b-4. This integrator will be described.

The video signal resulting from the reception

20   and decoding is supplied to an external video synch type synchronizing signal generator 7b-4-5 and to an adder 7b-4-6. The field intensity imaging signal, BER imaging signal and ghost imaging signal are supplied via gates 7b-4-1, 7b-4-2, 7b-4-3 to the adder 7b-4-6.

25   A display selector 7b-4-4 generates signals for individually selecting (ON/OFF) ones being displayed, of the field intensity imaging signal, BER imaging signal and ghost imaging signal. The external

video synch type synchronizing signal generator 7b-4-5
supplies the synchronizing signal C.Sync resulting from
extracting from the input video signal to the adder 7b-
4-6 and to the outside, and also a pulse of the time
5 base scale and guard interval for the ghost imaging
signal to the adder 7b-4-6. The gates 7b-4-1, 7b-4-2,
7b-4-3 respond to the selection signals from the
display selector 7b-4-4 to allow the field intensity
imaging signal, BER imaging signal and ghost imaging
10 signal to be passed therethrough or not. The adder 7b-
4-6 responds to the C.Sync to add the imaging signals
passed through the gates 7b-4-1, 7b-4-2, 7b-4-3, the
pulse signal of the scale and interval, and the video
signal produced by the reception and decoding to
15 produce a transmission-conditions superimposed imaging
signal so that each imaging signal can be displayed in
a certain size at a position.

        This transmission-conditions superimposed
imaging signal is displayed on a monitor. Thus, since
20 the operator can comprehensively view the reproduced
images of those imaging signals in association with
each other, the transmission-conditions can be
correctly grasped as compared with the case shown in
Fig. 10.

25   One example of the addition rates of those
signals in the adder 7b-4-6 will be given below.

        If all the signals fed to the adder 7b-4-6
are +5 V in digital level, the rates of the field

intensity imaging signal, BER imaging signal and ghost imaging signal are 0.2, the rates of the time scale signal and interval signal are 0.05, and the rate of the analog video signal of which the video portion is

5   about 0.7 V is one.

Fig. 13 is a block diagram of one embodiment of the external video synch type synchronizing signal generator 7b-4-5. This generator will be described.

In the external video synch type synchroniz-

10   ing signal generator 7b-4-5, a synchronizing signal extractor 7b-4-5-1 extracts the external synch signal from the input video signal. In addition, a synch signal generator 7b-4-5-2 produces the internal synch signal C.Sync in synchronism with the external synch

15   signal.

The pulse of the above time base scale and guard interval is similarly produced as in the above image integrator 7-4.

Fig. 14 is a block diagram of one embodiment

20   of the BER-to-image converter 7b-2 of the display position switching type. The portions different from the BER-to-image converter 7-2 will be described.

A display position pulse generator 7b-2-3 generates pulses b0 through b4 for the indication of

25   BER in synchronism with the sync signal C.Sync like the BER-to-image converter 7-2, but it also generates, by a mode switching signal, pulses b'0 through b'4 corresponding to another position. Fig. 15 schematically

shows the situation in which the images can be displayed by switching at different positions corresponding to these pulses b0 through b4, b'0 through b'4.

5   If the generator 7b-2-3 is used for NTSC, it makes logical processing by use of a 1/910 frequency dividing counter that counts at a clock of 14.3 MHz and is reset at each H-period, and a 1/525 frequency dividing counter that counts at a clock of 1/2 H and is

10 reset at each V-period.

        Thus, in the case of using the mode switching signal=High (mode 1), the blocks are displayed at a position corresponding to the pulse b0 through b4 on the upper right side. In the case of using the mode

15 switching signal=Low (mode 2), the blocks are displayed at a position corresponding to the pulse b'0 through b'4 on the lower right side.

        For example, as shown in Fig. 15, the b4 signal is displayed at a position of scanning lines 80-

20 th H through 96-th H, and of sample number 512-nd through 526-th sample. The b3 signal is displayed at a position of scanning lines 80-th H through 96-th H, and of sample number 528-th through 542-nd sample. The b2 signal is displayed at a position of scanning lines 80-

25 th H through 96-th H, and of sample number 544-th through 558-th sample. The b1 signal is displayed at a position of scanning lines 80-th H through 96-th H, and of sample number 560-th through 574-th sample. The b0

signal is displayed at a position of scanning lines 80-th H through 96-th H, and of sample number 576-th through 590-th sample.

In addition, the b'4 signal is displayed at a position of scanning lines 192-nd H through 208-th H, and of sample number 520-th through 534-th sample. The following signals b'3, b'2 and b'1 are displayed at positions in the same way. The signal b'0 is displayed at a position of scanning lines 192-nd H through 208-th H, and of sample number 584-th through 598-th sample.

Fig. 16 is a block diagram of one embodiment of a video/audio transmission system, having a combination of the transmission system according to the invention and a video codec, by which the afore-mentioned transmission-condition images are super-imposed on an MPEG decoded image before being displayed. Portions different from the transmission system using OFDM modulation system shown in Fig. 1 will be described.

On the transmission side, a video signal and an audio signal are fed to an MPEG-ENC (encoder) 101 M, where they are converted to compressed digital data D_{in} in synchronism with the reference clock CK_{TX} fed from the transmission-side processor 101. On the receiving side, the transmitted and received signal is demodulated by the receiving-side processor 203. The demodulated output D_{out} is supplied to an MPEG-DEC (decoder) 203 M for expansion. The video signal

expanded by the MPEG-DEC 203 M is supplied to the transmission-condition video superimposing device 7b that is the same as shown in Fig. 11, where it is superimposed on each condition imaging signal, and the

5   time scale and guard interval signal as shown in Fig. 2B to produce a transmission-condition superimposed video signal.

This transmission-condition superimposed video signal is displayed on the video display 11.

10   Thus, since each condition imaging signal and the received and decoded video signal can be comprehensively observed in association with each other, the operator is able to correctly grasp the transmission conditions.

15   According to the invention, since the field intensity, BER and ghost are converted to imaging signals, they can be displayed on a common type of video display, and hence they can be displayed in optimum sizes according to situations, if necessary.

20   Moreover, if the ghost imaging signal within a certain level range is displayed in a different way (with a different luminance level or hue) from signals occurring within other level ranges, the operator is able to quickly find the transmission condition that is

25   to be noted.

In addition, if the guard interval of the ghost imaging signal is displayed in a different way (with a different luminance level or hue) to distin-

guish from other condition imaging signals, the operator can promptly find the transmission condition that is to be looked out or considered.

Also, since the transmission-condition
5 measured data are converted to imaging signals, they can be recorded on video cassette recorders or other recording media, and thus a large amount of transmission-condition data measured and collected can be recorded easily and at low cost.

10 Therefore, since the ghost imaging signal, BER imaging signal and field intensity imaging signal can be displayed on a video monitor, the various condition images can be comprehensively seen in association with each other, and hence the operator can
15 correctly understand the transmission conditions.

Accordingly, the antenna alignment operator can effectively perform the alignment operation while viewing the imaged information on the screen.

Another embodiment of the ghost-to-image
20 converter different from the ghost-to-image converters 7-3, 7b-3 (Figs. 5 and 11) in the transmission-condition-to-image converter 7 and transmission-condition image superimposing device 7b (Figs. 2A and 11) will be described with reference to Figs. 27, 28
25 and 29.

Since the ghost-status imaging signal produced from the ghost-to-image converter 7-3 shown in Fig. 5 is vertically displayed as an image like a bar

graph on the left side of the screen as shown in Fig. 7, the resolution is limited by the number of scanning lines. Moreover, since the time base is displayed in the vertical direction, it is inconsistent with the

5 human sixth sense, so that in the alignment operation in which the operator needs swift decision, he additionally makes the mental operation to change the direction of time base in his mind though it is unconnected with the original operation.

10 Thus, in this embodiment, the ghost imaging signal indicative of a ghost status is displayed in the lateral direction with respect to the screen with the display resolution or display range magnified, and the time base is provided in the lateral direction.

15 Consequently, the alignment operator can view the ghost status with the same feeling as he watches the oscilloscope screen.

Fig. 27 is a block diagram showing the construction of the ghost-to-image converter 7a-3 for

20 lateral display according to the invention. Fig. 28 is a schematic diagram showing the image-displayed screen. Fig. 29 is a diagram showing the waveforms of signals.

The constructions of the other portions than the ghost-to-image converters 7-3, 7b-3 of the trans-

25 mission-condition-to-image converter 7 and transmission-condition image superimposing device 7b will not be described because they are the same as in Figs. 2, 5 and 11.

Referring to Fig. 27, the correlation output
signal Sc indicative of the ghost status is supplied to
and converted by an A/D converter 7a-3-1 into the
digital correlation output signal DSc of, for example,

5   8 bits. This signal DSc is supplied to an FIFO 7a-3-2.

The pulse FSTrc of frame period is supplied
to an input terminal of the write-in reset terminal of
the FIFO 7a-3-2. The digital correlation output signal
D'Sch from the FIFO 7a-3-2 is supplied to a comparator

10   7a-3-4. The output, or ghost level signal LEh from the
comparator 7a-3-4 is supplied to a gate 7a-3-5.

Moreover, the synchronizing signal C.Sync is
supplied to a clock (CK) reproducer 7a-3-6, an HD
extractor 7a-3-7 and a VD extractor 7a-3-8. The clock

15   produced from the CK reproducer 7a-3-6 is supplied to a
counter 7a-3-9. The output WE from the counter 7a-3-9
is supplied to the WE terminal of the FIFO 7a-3-2.

The output HD from the HD extractor 7a-3-7 is
supplied to a counter 7a-3-10. The output C-S from the

20   counter 7a-3-10 is supplied to a first decoder 7a-3-3.

The output VD from the VD extractor 7a-3-8 is
supplied to an H-counter 7a-3-11. The output C-H from
the H-counter 7a-3-11 is supplied to the first decoder
7a-3-3 and a second decoder 7a-3-12.

25   The first decoder 7a-3-3 supplies a read
reset signal RRST to the RR terminal of the FIFO 7a-3-
2, and a read enable signal RE to the RE terminal of
the FIFO 7a-3-2.

The output (D'Sch) from the FIFO 7a-3-2 is supplied to an input of the comparator 7a-3-4. The output Dhh from the second decoder 7a-3-12 is supplied to the other terminal of the comparator 7a-3-4. The

5 output LEh from the comparator 7a-3-4 is supplied to the gate 7a-3-5.

The CK reproducer 7a-3-6 reproduces a clock (CK) of, for example, 14.3 MHz from the synchronizing signal C.Sync. The counter 7a-3-9 divides the

10 frequency of the CK, and generates the WE signal with the period depending on that of the correlation output signal Sc. The HD extractor 7a-3-7 extracts the H-period component from the synchronizing signal C.Sync, and produces the HD signal with H-period. The counter

15 7a-3-10 is reset by the HD signal, and produces the counter signal C-S that increases at each CK period. The VD extractor 7a-3-8 extracts the V-period component from the synchronizing signal C.Sync, and produces the VD signal with V-period. The H-counter 7a-3-11 is

20 reset by the VD signal, and produces the counter signal C-H that increases at each H-period.

The decoder 7a-3-3 receives the counter signals C-S, C-H and produces the read reset signal RRST that takes level "Low" in 1H period at each CK

25 period within the interval from the m-th scanning line to the (m+n)-th scanning line in each V-period as shown in Fig. 29. Thus, the read address to the FIFO 7a-3-2 is initialized into address 0.

In addition, the read enable signal RE that takes level "High" during each interval from the m-th scanning line to the (m+n)-th scanning line forces the read address to the FIFO 7a-3-2 to proceed, with the

5 result that the output D'Sch as the correlation output signal Sc is read from the FIFO 7a-3-2.

The decoder 7a-3-12 receives the counter signal C-H, and produces level 1a at the m-th scanning line as output Dhh, and then reduces the level by i at

10 each H. At the (m+n)-th scanning line, the decoder produces output Dhh of 1a minus ni.

At this time, the comparator 7a-3-4 compares the D'Sch as the correlation output Sc and the decoder output Dhh, and produces the signal LEh that becomes

15 level "High" when the condition of D'Sch > Dhh is satisfied.

In other words, as illustrated in Fig. 29, since the D'Sch is lower than or equal to Dhh during all the m-th H, the signal LEh remains level "Low".

20 During the (m+1)-th H, the condition of D'Sch > Dhh is satisfied only in a short period, t_1 at the center of that H, and at this time the signal LEh becomes level "High". During the (m+2)-th H, since the condition of D'Sch > Dhh is satisfied in a wider period, t_2 than the

25 previous short period t_1, the signal LEh takes level "High" for more time. Thereafter, after these operations are repeated, the waveform of the correlation output signal Sc is expressed by such a scanning line

structure as shown in Fig. 29 at LEh.

Thus, the correlation output signal Sc indicative of the ghost status can be converted to an image, and as shown in Fig. 28, the ghost image can be

5   laterally displayed with respect to the time base on the screen.

In Fig. 29, for simple explanation, only the main wave of the correlation output signal Sc indicative of the ghost status is expressed as the signal LEh

10 in the form of scanning line structure.

Another embodiment of the converter than the transmission-condition-to-image converter 7, and transmission-condition image superimposing device 7b (Figs. 2A and 11) will be described with reference to

15 Figs. 30 through 40.

When we try to grasp the transmission path conditions from the ghost imaging signal, BER imaging signal and field intensity imaging signal, the operator needs to always fix his eyes on the monitor screen

20 against abnormal state occurrence. This becomes a considerable burden on the operator.

In addition, when an abnormal thing occurs suddenly for a very short time, the human cannot perceive it as an abnormal state through the eyes, or

25 the operator cannot grasp correct transmission path conditions.

Thus, in this embodiment, when the apparatus detects that the information indicative of a ghost

imaging signal or others has reached a predetermined
unsatisfactory level because of poor transmission
condition, it superimposes this abnormal transmission-
condition waveform on the current normal transmission-
5 condition waveform and keeps it residually displayed as
it is for a certain time so that the operator can
understand the transmission path characteristics.

In addition, warning sound is emanated at the
time of this abnormal state, notifying the operator of
10 the abnormal thing.

Fig. 30 is a block diagram of the construc-
tion of the transmission-condition-to-image converter
7a having the abnormality detection and residual
displaying functions according to the invention. The
15 transmission-condition-to-image converter 7a is
different from the transmission-condition-to-image
converter 7 and transmission-condition image super-
imposing device 7b in that an abnormal state detector &
residual image display 7a-5 and abnormal state image
20 integrator 7a-6 are further added.

In this converter, it is not always necessary
to simultaneously display the ghost imaging signal, or
abnormal state image together with the field intensity
and BER imaging signals. This converter can be
25 implemented by hardware, DSP (Digital Signal Processor)
or one-chip microcomputer.

Referring to Fig. 30, the correlation output
signal Sc indicative of the ghost status, and the pulse

FSTrc with frame period are supplied to the abnormal
state detector & residual image display 7a-5.

The output S'c of the ghost-to-image
converter 7a-3 is connected to the abnormal state
5   detector & residual image display 7a-5. The output
from the image integrator 7a-4 and the output CNT from
the abnormal state detector & residual image display
7a-5 are supplied to the abnormal state image
integrator 7a-6.

10   The abnormal state detector & residual image
display 7a-5 detects the abnormal transmission-
condition on the basis of the ghost condition imaging
signal Sc' produced from the ghost-to-image converter
7a-3. When detecting the abnormal state, it produces
15   an abnormal state imaging signal. When detecting no
signal, it produces a level "Low".

The abnormal state image integrator 7a-6 adds
the transmission-condition imaging signal produced from
the image integrator 7a-4, and the abnormal state
20   imaging signal produced from the abnormal state
detector & residual image display 7a-5, and produces a
transmission-condition imaging signal including the
abnormal state imaging signal.

Fig. 32 is a block diagram of the construc-
25   tion of the abnormal state detector & residual image
display 7a-5. This construction will be described.

The correlation output signal Sc, pulse FSTrc
with frame period, and synchronizing signal C.Sync are

supplied to an abnormal state residual display 7a-5B.

The ghost imaging signal Sc' is supplied to an abnormal state detector 7a-5A. The outputs C-S and C-H, which will be described later, from the abnormal

5 state residual display 7a-5B are supplied to the abnormal state detector 7a-5. The output ABN from the abnormal state detector 7a-5A is supplied to the abnormal state residual display 7a-5B, warning sound generator 7a-5C and timer circuit 7a-5D. The output G2

10 from the timer circuit 7a-5D is supplied to the abnormal state residual display 7a-5B.

The abnormal state detector 7a-5A detects the position of ghost condition imaging signal Sc' displayed on the screen on the basis of the outputs C-S

15 and C-H which will be described later.

The abnormal state detector 7a-5A, when the ghost imaging signal Sc' is displayed at an abnormal position (for example, outside the guard interval on the screen shown in Fig. 31), detects this situation as

20 abnormal state, and produces ABN of level "High". When it is displayed at a normal position, for example, within the guard interval, the abnormal state detector 7a-5A detects this situation as normal state, producing signal ABN of level "Low".

25 The abnormal state imaging signal CNT from the abnormal state residual display 7a-5B is level "Low" when the signal ABN is level "Low" (normal state). When the signal ABN is level "High" (when

abnormal state is detected), the abnormal state residual display 7a-5B generates the CNT of level "High" as described later.

5 The warning sound generator 7a-5C generates warning sound ALARM when the signal ABN is High level. The timer circuit 7a-5D controls the way that the abnormal state imaging signal CNT is displayed. For example, it controls this signal to be continuously displayed for a predetermined time or to be 10 intermittently displayed in a blinking manner for a certain time just before the displaying ends.

Fig. 33 is a block diagram of one example of the construction of the abnormal state residual display 7a-5B according to the invention. This example will be 15 described.

This construction corresponds to the addition of the FIFO write-in controller 7a-5-13 and gate 7a-5-14 to the ghost-to-image converter 7a-3 shown in Fig. 27.

20 The correlation output signal Sc is supplied to, and converted by the A/D converter 7a-5-1 into a digital correlation output signal DSc of, for example, 8 bits. The signal DSc is supplied to an FIFO 7a-5-2.

The digital correlation output signal D'Schb 25 from the FIFO 7a-5-2 is supplied to a comparator 7a-5-4. The ghost level signal LEhb from the comparator 7a-5-4 is supplied to a gate 7a-5-5. The output Lehb' from the gate 7a-5-5 is supplied to the gate 7a-5-14.

The pulse FSTrc with frame period is supplied to the FIFO write-in controller 7a-5-13. The outputs WRSTb and WEb from the FIFO write-in controller 7a-5-13 are supplied to the write-in reset terminal WR and

5 write-in enable terminal WE of the FIFO 7a-5-2, respectively.

The synchronizing signal C.Sync is supplied to a clock (CK) reproducer 7a-5-6, an HD extractor 7a-5-7 and a VD extractor 7a-5-8. The clock produced from

10 the CK reproducer 7a-5-6 is supplied to a counter 7a-5-9. The output WE from the counter 7a-5-9 is supplied to the FIFO write-in controller 7a-5-13.

The output HD from the HD extractor 7a-5-7 is fed to a counter 7a-5-10. The output C-S from the

15 counter 7a-5-10 is supplied to a first decoder 7a-5-3.

The output VD from the VD extractor 7a-5-8 is fed to a H-counter 7a-5-11. The output C-H from the H-counter 7a-5-11 is supplied to the first decoder 7a-5-3 and a second decoder 7a-5-12.

20 The first decoder 7a-5-3 supplies the read reset signal RRST to the RR terminal of the FIFO 7a-5-2, and the read enable signal RE to the RE terminal of the FIFO 7a-5-2. The output G1 from the first decoder 7a-5-3 is fed to the gate 7a-5-5. The output Dhh from

25 the second decoder 7a-5-12 is supplied to the comparator 7a-5-4.

The operation of the abnormal state residual display 7a-5B will be described. The same portions as

those of the ghost-to-image converter 7a-3 shown in Fig. 27 will not be described because they operate in the same way as those of the converter 7a-3.

The FIFO 7a-5-2 is an FIFO memory for storing the abnormal ghost imaging signal for a predetermined time.

The FIFO 7a-5-2 makes normal writing-in operation when the transmission condition is normal, and updates the received digital correlation output signal DSc indicative of ghost status. When the transmission condition is abnormal, the FIFO 7a-5-2 stops write-in operation for a certain time, and holds the abnormal ghost imaging signal waveform for a certain time. The reading operation of the FIFO 7a-5-2 is the same as in Fig. 27. That is, it receives the signals RE and RRST for read control from the first decoder 7a-5-3, and makes reading operation on a steady basis.

The FIFO write-in controller 7a-5-13 controls the writing-in operation of the FIFO 7a-5-2 for storing the abnormal ghost imaging signal. The write-in control signals WRSTb and WEb from the FIFO write-in controller 7a-5-13 switch between the writing operation and writing-stop operation as above in response to the output ABN from the abnormal state detector 7a-5A which will be described later.

The comparator 7a-5-4 makes the same operation on the output D'Schb from the FIFO 7a-5-2 as

in Fig. 27. The gate 7a-5-5 receives output LEhb from the comparator 7a-5-4 and forcibly makes it level "Low" in the blanking period.

The gate 7a-5-14 forcibly makes its output CNT level "Low" when the transmission condition is normal, but processes the output Lehb' from the gate 7a-5-5 to produce abnormal imaging signal CNT only when the transmission condition is abnormal.

The generation of the output Lehb' as the abnormal imaging signal CNT will be described with reference to the timing chart of Fig. 39.

Fig. 39 shows the waveforms of signals Dhh, D'Sch and LEh in the ghost-to-image converter 7a-3 shown in Fig. 27 in addition to other waveforms.

As described in Fig. 29, the decoder 7a-5-3 responds to the input counter signals C-S and C-H to generate the read reset signal RRST that takes level "Low" for one CK period of time at every Horizontal scanning of the interval from the m-th scanning line to the (m+n)-th scanning line. This signal initializes the read address to the FIFO 7a-5-2 into 0. In addition, the read enable signal RE that takes level "High" during the period from the m-th scanning line to the (m+n)-th scanning line is also supplied to the FIFO 7a-5-2, causing the read address to the FIFO 7a-5-2 to progress. Consequently, the signal D'Schb is read from the FIFO 7a-5-2 as the abnormal imaging signal.

The decoder 7a-5-12 responds to the input

counter signal C-H to generate level 1a at the m-th scanning line, and then reduces its output Dhh by i at every Horizontal scanning until level 1a minus ni at the (m+n)-th H.

5 The comparator 7a-5-4 compares the output D'Schb from the FIFO 7a-5-2 and the output Dhh from the decoder 7a-5-12, and produces the signal LEhb that takes level "High" when the condition of D'Schb > Dhh is satisfied.

10 In other words, as shown in Fig. 39, since the D'Schb is smaller than Dhh for all H period of the m-th scanning period, the signal LEhb remains level "Low". Then, only during a short time t1 of 1 H period of the (m+1)-th scanning line, the D'Schb is larger

15 than Dhh, and thus the LEhb becomes level "High". During a relatively long time t2 of 1 H of the (m+2)-th scanning line, the condition of D'Schb > Dhh is satisfied, and thus the signal LEhb takes level "High". Thereafter, after these operations are repeated, the

20 abnormal state imaging signal waveform as the signal LEhb can be expressed in a form of scanning-line structure as illustrated.

When the transmission condition is normal, the renewal data is written in the FIFO 7a-5-2, and

25 thus the output D'Schb remains the current ghost-status waveform. Therefore, the abnormal state imaging signal LEhb is produced as the same signal as the ghost condition imaging signal LEh. At this time, however,

the gate 7a-5-14 forcibly makes the signal Lehb' level "Low", and thus the abnormal state imaging signal is not displayed when the state is normal.

Fig. 35 is a block diagram of one example of 5 the specific construction of the abnormal state detector 7a-5A. This detector will be described.

This detector is constructed to divide the display screen into 8 regions, A through H, as shown in Fig. 34, and detect a region in which the abnormal 10 state imaging signal is displayed so that whether the transmission condition is normal or abnormal can be known.

The ghost imaging signal Sc' is supplied to the abnormality detection signal generator 7a-5A-3. 15 The signals C-S and C-H are fed together to decoders 7a-5A-1, 7a-5A-2. The eight output signals Ra, Rb,..., Rh from the decoder 7a-5A-1, and the output signals RESET and F-END from the decoder 7a-5A-2 are supplied to the abnormality detection generator 7a-5A-3. Here, 20 the number of the output signals from the decoder 7a-5A-1 corresponds to that of the regions into which the display screen is divided.

The decoder 7a-5A-1 responds to the signals C-S and C-H to produce the eight signals Ra, Rb,..., Rh 25 that indicate the currently scanned regions of the display screen. If the region A of the eight regions in Fig. 34 is currently scanned, only signal Ra of the eight output signals is level "High", and the other

signals Rb, Rc,..., Rh are level "Low".

The decoder 7a-5A-2 generates the signals RESET and F-END that are level "High" when the video signal is within the V-blanking period at around the

5 end of frame, and supplies them to the abnormality detection signal generator 7a-5A-3, thereby updating its output signal ABN at every frame unit.

Fig. 36 is a block diagram of one example of the specific construction of the abnormality detection

10 signal generator 7a-5A-3. The ghost imaging signal Sc' is fed to eight AND gates 5A-3-1.

The eight output signals Ra, Rb,..., Rh from the decoder 7a-5A-1 are supplied to the eight AND gates 5A-3-1, respectively.

15 The signal RESET is fed to eight SR flip-flop (SR/FF) 5A-3-2. The signal F-END is supplied to a D-flip-flop (D-FF) 5A-3-4.

The output signals from the eight AND gates 5A-3-1 are supplied to the eight SR/FF 5A-3-2, and the

20 outputs from the SR/FF 5A-3-2 are supplied to an abnormality condition detector 5A-3-3. The output S-ABN from the abnormality condition detector 5A-3-3 is fed to the D-FF 5A-3-4.

The eight AND gates 5A-3-1 take the logical

25 products of the signal Sc' and signals Ra, Rb,..., Rh to produce logical product outputs ANDa, ANDb,..., ANDh, respectively.

When these output signals are supplied to the

set terminals of the corresponding SR/FF 5A-3-2, the

SR/FF 5A-3-2 generate signals SRa, SRb,..., SRh that

indicate the presence or absence of ghost condition

waveform in each region. Each of these signals

5   indicates that the ghost waveform is displayed or not

in the corresponding region when it is level "High" or

level "Low", respectively.

The abnormality condition detector 5A-3-3

detects whether the abnormality condition has occurred

10   in the ghost imaging signal Sc', on the basis of these

signals SRa through SRh. Thus, the detector 5A-3-3

generates the signal S-ABN that becomes level "High"

when the abnormal condition is detected, and level

"Low" when it is not detected.

15   This signal S-ABN is supplied to the D-FF 5A-

3-4, and the F-END signal is also applied thereto as an

enable signal, so that the D-FF 5A-3-4 generates the

signal ABN that contains the abnormality detected

result updated at every frame.

20   After the ABN signal is updated in response

to the F-END signal, the SR/FF 5A-3-2 are reset by the

RESET signal.

Fig. 37 is a block diagram of one example of

the specific construction of this abnormality condition

25   detector 5A-3-3. This detector will be described. The

signal SRb is fed to a NOT gate 5A-3-3-1, the signal

SRc to a NOT gate 5A-3-3-2, and the signal SRd to a NOT

gate 5A-3-3-3. The five signals SRa, SRe, SRf, SRg,

SRh are supplied to an AND gate 5A-3-3-4.

The outputs SRb', SRc' and SRd' from the NOT gates 5A-3-3-1, 5A-3-3-2, and 5A-3-3-3 are fed to the AND gate 5A-3-3-4.

5   This abnormality condition detector 5A-3-3 is designed so that for example, the state in which the ghost waveform is displayed in the regions A and E through H of the eight regions A through H shown in Fig. 34, but is not displayed in the regions B, C and D

10   can be detected as abnormality.

Here, the range from region B to region D in Fig. 34 corresponds to the guard interval range in Fig. 31. Thus, when the peak of the correlation output waveform indicative of ghost status is displayed

15   shifted more to the left end (region A) of the display screen, or when it is displayed far away out of the guard interval, the detector can detect that the transmission condition is more seriously abnormal.

Thus, the abnormality condition detector 5A-

20   3-3 makes NOT operation on the signals SRb, SRc, SRd by the NOT gates 5A-3-3-1 through 5A-3-3-3, and takes the logical product of signals SRa, SRb', SRc', SRd', SRe through SRh by the AND gate 5A-3-3-4, to thereby detect whether the abnormality occurs in the ghost imaging

25   signal, thus producing the signal S-ABN.

This signal S-ABN becomes level "High" when an abnormality is detected, and level "Low" when no abnormality is detected.

The operation of the abnormality condition detector 5A-3-3 will be described in more detail with reference to Figs. 34 and 40.

Let us consider that as an example, the
5 display screen is divided into eight regions of A through H, and a ghost waveform is displayed as shown in Fig. 34. For the sake of simple explanation, the full screen is assumed to be displayed by six scanning lines without interlaced scanning. Fig. 40 is a timing
10 chart of signals produced at this time.

The signals Ra through Rh are level "High" when the regions A through H are scanned, respectively. The signal F-END becomes level "High" for a predeter-mined time in the V blanking period after the end of
15 full-screen scanning. The signal RESET becomes level "High" for a certain time in the V-blanking period after the signal F-END.

The signals SRa through SRh are level "High" when the signal Sc' becomes level "High" and when each
20 of the signals Ra through Rh is level "High", respec-tively. The signal S-ABN becomes level "High" when the signals SRa through SRh satisfy the above condition.

The signal ABN is the state of the signal S-ABN held (updated) by the leading edge of the signal F-
25 END. The signals SRa through SRh are reset by the leading edge of the signal RESET, and thus the signal S-ABN is reset to be level "Low".

Fig. 38 is a block diagram of one example of

the construction of the FIFO write-in controller 7a-5-13. This controller will be described. The signal FSTrc is supplied to a selector 7a-5-13-2. The clock CK is supplied to a selector 7a-5-13-3.

5   The signal ABN is supplied to the selectors 7a-5-13-2, 7a-5-13-3. The outputs WES and WRS from a write-in stop signal generator 7a-5-13-1 are fed to the selectors 7a-5-13-2, 7a-5-13-3.

        The ABN signal indicative of abnormality 10 controls the selectors 7a-5-13-2, 7a-5-13-3 to select ones of the input signals.

        When the ABN is level "Low", or when the transmission condition is normal, the outputs WEb and WRb from the selectors 7a-5-13-2, 7a-5-13-3 are signals 15 FSTrc and CK, respectively. Thus, the FIFO 7a-5-2 shown in Fig. 33 is controlled to be normally written in.

        When the ABN signal is level "High", or when the transmission condition is abnormal, the outputs WEb 20 and WRb from the selectors 7a-5-13-2, 7a-5-13-3 are the signals WES and WRS of level "High" from the write-in stop signal generator 7a-5-13-1. Thus, the FIFO 7a-5-2 shown in Fig. 33 is stopped from being written in.

        A modification of the transmission-condition- 25 to-image converter 7a will be described with reference to Figs. 41 and 42.

        A transmission-condition-to-image converter 7a' shown in Fig. 41 has a ghost-to-image converter/

abnormality detector & residual image display 7a-7

provided to include the operation blocks common to the

ghost-to-image converter 7a-3 and abnormality detector

& residual image display 7a-5. Fig. 42 shows a

5 specific construction of this ghost-to-image converter/

abnormality detector & residual image display 7a-7.

As illustrated in Fig. 42, the A/D converter

7a-5-1, decoders 7a-5-3, 7a-5-12, CK reproducer 7a-5-6,

HD-extractor 7a-5-7, VD-extractor 7a-5-8, counters 7a-

10 5-9, 7a-5-10, and H-counter 7a-5-11 can be omitted

because they can be shared.

The operation of the transmission-to-video

converter 7a' is the same as the transmission-to-video

converter 7a, and thus will not be described.

15 Thus, according to the transmission-to-video

converters 7, 7a, 7a' and transmission image super-

imposing device 7b mentioned above, since the ghost

imaging signal, BER imaging signal and filed intensity

imaging signal are displayed on a video monitor, the

20 conditions, or status of the imaging signals can be

comprehensively viewed in associated with each other,

so that the transmission condition can be correctly

grasped. However, we further need to consider the

following points.

25 Recently, there is a trend toward the change

of length of the guard interval (GI) as a buffer band

against the mixing of reflected waves according to the

transmission situations in order to cope with various

transmission conditions.

That is, for example, a signal format of more adequate GI length is selected according to the information contents being transmitted, and trans-

5　mission conditions from one signal format in which a guard interval waveform of 48 samples is added to the time base waveform of 1024 samples to form a time base waveform of 1072 samples/symbol in total, and the other signal format in which a guard interval waveform of 96

10　samples is added thereto to form a time base waveform of 1120 samples/symbol in total.

When the GI length is changed according to transmission conditions by switching, a GI mode signal for determining the GI length is supplied to the

15　transmission path encoder and guard adder of the transmitting-side processor 101, and to the synchro-nizing detector & correlator and transmission path decoder of the receiving-side processor 203, shown in Figs. 1 and 17, thereby changing the GI length.

20　However, the transmission-condition-to-image converters 7, 7a, 7a' and transmission image super-imposing device 7b do not consider the transmission mode for changing the GI length according to the transmission situations, and the GI mode signal is not

25　applied. Therefore, when the GI length is changed, the guard interval displayed at the position corresponding to the ghost imaging signal waveform cannot be changed in association therewith, and thus the transmission

condition cannot be correctly understood.

Thus, according to the invention, a transmission-condition-to-image converter is proposed which can solve the above problem so that the guard interval

5   can be displayed at the position corresponding to the ghost imaging signal waveform even when the GI length is changed, and hence that the transmission condition can be correctly grasped. This converter will be described with reference to Figs. 43 through 52.

10   The transmission-condition-to-image converter is given a function to change the display position range in which the guard interval is displayed according to the change of the GI length by switching. Thus, even when the GI length is changed, the positional

15   range in which the guard interval is displayed can be automatically changed by this function in association with the ghost imaging signal.

Fig. 43 is a block diagram of the construction of a transmission-condition-to-image converter 7c

20   capable of automatically detecting the GI mode signal, according to the invention. The portions equivalent to those in the transmission-condition-to-image converter 7 shown in Fig. 2A will not be described.

The correlation output signal Sc and pulse

25   FSTrc with frame period are supplied to a ghost-to-image converter 7c-3. The FSTrc signal is also fed to a guard interval mode detector 7c-8. The output, GI mode signal from the guard interval mode detector 7c-8

is supplied to the ghost-to-image converter 7c-3 and an
image integrator 7c-4. The output from the ghost-to-
image converter 7c-3 is supplied to the image
integrator 7c-4.

5   The synchronizing signal C.Sync from the
image integrator 7c-4 is fed to the sync input
terminals of a field-intensity-to-image converter 7c-1,
a BER-to-image converter 7c-2 and the ghost-to-image
·converter 7c-3. The image integrator 7c-4 generates a
10 transmission-condition imaging signal.

       The field-intensity-to-image converter 7c-1,
BER-to-image converter 7c-2, ghost-to-image converter
7c-3 convert signals of different transmission condi-
tions to imaging signals according to the synchronizing
15 signal C.Sync, respectively. The image integrator 7c-4
combines the imaging signals, and adds a sync signal
for video image to those combined imaging signals. Or
this integrator superimposes those imaging signals on
an externally applied video signal.

20   The guard interval mode detector 7c-8 detects
the GI mode corresponding to the guard interval length,
and sends the resulting GI mode signal to associated
blocks.

       The transmission-condition-to-image converter
25 7c of this construction automatically detects the GI
mode signal corresponding to the range of the guard
interval from the FSTrc signal by use of the guard
interval detector 7c-8. In addition, the converter 7c

changes the displayed range and length of the guard

interval, the range (alarm range) in which any one or

more transmission conditions are abnormal, and the

sampling period of correlation output signal Sc by

5   switching in accordance with the GI mode signal.

Fig. 44A shows an example of the screen

displayed when the guard interval is 3 μ sec. In this

case, the guard interval length is three graduations,

and the alarm range is out of the guard interval.

10   Fig. 44B shows an example of the screen

displayed when the guard interval is 6 μ sec. In this

case, the guard interval is as long as 6 graduations,

and the alarm range is displayed narrower on the right

side of the screen away from the guard interval.

15   Fig. 45 is a block diagram of a specific

construction of the guard interval mode detector 7c-8.

The FSTrc signal is supplied to the reset terminal of a

counter 7c-8-1 and the enable terminal of a latch 7c-8-

2. The output terminal of the counter 7c-8-1 is

20 connected to the D-input terminal of the latch 7c-8-2.

A clock (CK) source 7c-8-4 is connected to the CK input

terminal of the counter 7c-8-1. The output terminal of

the latch 7c-8-2 is connected to the input terminal of

a determiner 7c-8-3.

25   The operation of the guard interval mode

detector 7c-8 will be described. If the CK frequency

of the CK source 7c-8-4 is 16 MHz, since the FSTrc

signal occurs with a period of 60.3 m sec, the maximum

value that the counter 7c-8-1 counts is about 964800.

The counter 7c-8-1 is once reset by the next FSTrc signal into 0, but the latch 7c-8-2 holds the value just before the resetting, or the maximum value

5   of the counter 7c-8-1.

Therefore, since the determiner 7c-8-3 detects the value of the output PK from the latch 7c-8-2, the associated guard interval can be determined.

Since the maximum value of 964,800 is not

10 always produced depending on the frequency accuracy of the CK source 7c-8-4, an allowance of ± 21,600 is given for the determination.

Fig. 46A shows the relation among the FSTrc, the counter output and the latch output when the

15 maximum value of the counter 7c-8-1 is about 964,800 that corresponds to a guard interval of 3 μ sec.

Fig. 46B shows the relation among the FSTrc, the counter output and the latch output when the maximum value of the counter 7c-8-1 is about 1,008,000

20 that corresponds to a guard interval of 6 μ sec.

Thus, the GI mode can be decided by discriminating the output values of the latch 7c-8-2, or the maximum values of the counter 7c-8-1.

Fig. 47 is a block diagram of a specific

25 construction of the ghost-to-image converter 7c-3. This converter will be described. The CK signal from a CK reproducer 7c-3-6 is supplied to a counter 7c-3-9. The GI mode signal is supplied to the counter 7c-3-9.

The output WE signal from the counter 7c-3-9 is fed to the WE terminal of an FIFO 7c-3-2.

Since the change of the correlation output signal Sc usually depends on the symbol period, the

5 increase of the guard interval length (from 3 μ sec to 6 μ sec) will result in the change of ghost imaging signal from 67 μ sec to 70 μ sec.

The counter 7c-3-9 changes the period with which the WE signal occurs in accordance with that

10 change, and hence the sampling period is changed according to the GI mode signal.

Fig. 48 shows a specific construction of the counter 7c-3-9. Referring to Fig. 48, the CK signal is supplied to the CK terminal of a counter 7c-3-9-1. The

15 output from the counter 7c-3-9-1 is fed to a decoder 7c-3-9-2.

The output from the decoder 7c-3-9-2 is supplied to the reset terminal RST of the counter 7c-3-9-1, and to the outside as the WE signal. The GI

20 signal is supplied to the decode value switching terminal of the decoder 7c-3-9-2.

The operation of each part of the counter 7c-3-9 will be described. The counter 7c-3-9-1 counts the CK signal when the reset terminal RST is at level

25 "High".

The decoder 7c-3-9-2 generates, for example, level "Low" when 1,071 for 1,072 samples/symbol or 1,119 for 1,120 samples/symbol is applied according to

the GI mode signal. When the reset terminal is at
level "Low", the content of the counter 7c-3-9-1 is
reset back to zero.

The result is that the counter 7c-3-9-1

5 repeats counting 0-1,071 or 0-1,119.

Fig. 49A shows the output WE from the counter
7c-3-9 when the guard interval is 3 μ sec. As shown in
Fig. 49A, the WE signal becomes level "Low" with a
period of 67 μ sec.

10 Fig. 49B shows the output WE from the counter
7c-3-9 when the guard interval is 6 μ sec. From Fig.
49B, it will be seen that the WE signal becomes level
"Low" with a period of 70 μ sec.

Fig. 50 is a block diagram of a specific

15 construction of the image integrator 7c-4. The field
intensity imaging signal, BER imaging signal and ghost
imaging signal are supplied to an adder 7c-4-6 via
gates 7c-4-1, 7c-4-2 and 7c-4-3, respectively.

A display selector 7c-4-4 generates add-

20 on/off signals that control the field intensity imaging
signal, BER imaging signal and ghost imaging signal to
be separately added or not, respectively.

The GI mode signal is fed to an external
video sync type synchronizing signal generator 7c-4-5.

25 The video signal is supplied to the external video sync
type synchronizing signal generator 7c-4-5 and adder
7c-4-6. The external video sync type synchronizing
signal generator 7c-4-5 supplies the synchronizing

signal C.Sync to the outside. It also supplies a display signal of the time scale and guard interval to the adder 7c-4-6.

The gates 7c-4-1, 7c-4-2, 7c-4-3 are

5 controlled by the display selector 7c-4-4 to allow the input imaging signals to be passed therethrough or not. The signals passed through the gates 7c-4-1, 7c-4-2, 7c-4-3 are added together with the C.Sync signal, by the adder 7c-4-6, to produce the transmission-condition

10 imaging signal.

An example of the addition rates of signals in the adder 7c-4-6 will be shown. If the signals to be applied are all +5 Volts in digital level, the rates of the field intensity imaging signal, BER imaging

15 signal and ghost imaging signal are 0.2, the rates of the time scale signal and guard interval signal are 0.05, and the rate of the C.Sync signal is 0.1. Thus, the imaging signal of about 1 Volt$_{p-p}$ including the sync portion can be produced.

20 Fig. 51 is a block diagram of a specific construction of the external video sync type synchro-nizing signal generator 7c-4-5. This generator will be described.

A sync extractor 7c-4-5-1 extracts an

25 extracted sync signal from the input video signal. This sync signal is supplied to a counter 7c-4-5-2. The counter 7c-4-5-2 is reset by the vertical sync signal. The output from the counter 7c-4-5-2 is fed to

decoders 7c-4-5-3, 7c-4-5-4, 7c-4-5-5.

The outputs of, for example, 3 μ sec, 6 μ sec and 12 μ sec of guard interval length, from the decoders 7c-4-5-3, 7c-4-5-4 and 7c-4-5-5 are supplied to a selector (SEL) 7c-4-5-6, and thereby any one is selected in accordance with the GI mode signal as an output of each different guard interval length.

Fig. 52A shows a guard interval length signal of 3 μ sec. In this example, this signal is displayed as a band shape of a range surrounded by the 220-th and 230-th scanning lines as counted from the bottom of the display screen, and by the 400-th and 580-th pixels in the lateral direction.

Fig. 52B shows a guard interval length signal of 6 μ sec. In this example, this signal is displayed as a band shape of a range surrounded by the 220-th and 230-th scanning lines as counted from the bottom of the display screen, and by the 400-th and 760-th pixels in the lateral direction.

The alarm ranges shown in Figs. 44A and 44B are switched by the same method. Although this embodiment automatically detects the guard interval, and switches modes for each portion, the GI mode signal may be changed manually.

According to the embodiments of the invention mentioned above, since a digital transmission system can be produced in which the field intensity, BER and ghost status indicative of the levels/presence or

absence of reflected waves can be converted to different transmission-condition imaging signals and displayed so that those transmission-condition imaging signals or plus the received/decoded video signal can

5 be comprehensively observed in association with each other, the alignment operation can be more correctly and easily performed. In addition, a digital transmission system having the function to alarm when the transmission condition is abnormal can be produced, and

10 thus the transmission path characteristics can be grasped more correctly and easily.

While the OFDM system digital transmission has been described as an example, the present invention can be applied not only to this multi-carrier system

15 such as OFDM but also to a single-carrier digital system. The following example can be considered as the ghost status signal detection method in the single-carrier system.

Ghost information is derived from the

20 received signal by self-correlation processing and by using the preamble waveform component in a transmission system including a symbol mode in which the modulated signal includes periodical waveform components with respect to time, for example, in the single QAM system

25 disclosed in U.S. Patent No. 5,946,350.

With reference to drawings, a description will be made of an embodiment in which the ghost status imaging signal, and BER and field intensity imaging

signals are transmitted together with the video signals
that are transmitted from the outside broadcast vans 51
and 52 via the relaying station 53 to the broadcast
station 54 as shown in Fig. 53. In this embodiment,

5   since the program director in the broadcast station 54
can view the information of ghost status, BER and field
intensity on the display, he can correctly and easily
decide to select a satisfactorily transmitted video
signal from the video signals that are transmitted from

10 a plurality of outside broadcast vans. Like elements
corresponding to those in the above-mentioned embodi-
ments have fundamentally the same functions, and thus
will not be described.

        Fig. 55 is a block diagram of the whole

15 construction of another embodiment according to the
invention. Figs. 56A, 56B and 56C show output video
signals at each portion and displayed screens, respec-
tively. This embodiment will be described in detail.

        The transmission side such as outside

20 broadcast vans has the MPEG-ENC 101M and the trans-
mission-side processor 101. The receiving side of the
first relaying station built on, for example, a hill
has the receiving-side processor 203, the MPEG-DEC
203M, and the transmission-condition images super-

25 imposing device 7T. The signal processings from the
transmission-side processor 101 to the receiving-side
processor 203, and to transmission-condition images
superimposing device 7T are the same as in the

embodiment described with reference to Fig. 1 or Fig.
16.

The AGC control signal Sa indicative of a
received field intensity, correlation-calculated signal

5   Sc indicative of mixture status of reflected waves
(ghost), and signal Sb indicative of BER status, which
are produced from the receiving-side processor 203, are
supplied to the transmission-condition images super-
imposing device 7T. The FSTrc pulse as the operation

10 timing reference from the receiving-side processor 203
is also supplied to the transmission-condition images
superimposing device 7T. The video output V_i (Fig. 56A)
from the MPEG-ENC 203M is fed as the video signal to
the transmission-condition images superimposing device

15 7T. The video output V_i is not limited to the output
from the MPEG-ENC 203M, but may be an externally fed
video signal from other video apparatus.

The video signal and audio signal received by
the receiving-side of the relaying station are trans-

20 mitted directly or via a plurality of other relaying
stations (not shown) to the final receiving station, or
broadcast station having studios. This transmission is
made by means of, for example, analog FPU of microwave
band.

25   The superimposed information extractor &
transmission-condition-to-image converter 7R is
provided on the final receiving station, or studio
side.

The transmission-condition images super-
imposing device 7T receives the correlation-calculated
signal Sc indicative of the mixture of reflected waves
(ghost-status), and signals Sa indicative of the field

5   strength, Sb indicative of the BER state together with
the reference signal FSTrc indicative of pulses in
frame period from the receiving-side processor 203, and
it superimposes the information of these transmission
conditions on the vertical blanking (VBL) period, out

10   of the video effective period, of the video signal
(Fig. 56A) that is fed from the MPEG-ENC 203M. The
video signal Vs (Fig. 56B) with the transmission-
conditions information superimposed is transmitted from
a predetermined video transmitter 203T to the studio

15   side.

On the studio side, a predetermined video
receiver 300 produces a video signal Vs' by receiving
the transmitted signal from the relaying station. The
superimposed information extractor & transmission-

20   condition-to-image converter 7R extracts, from the
video signal Vs', information Sa', Sb' and Sc' indica-
tive of transmission-conditions superimposed on the VBL
period. Then, it receives the extracted information
Sa', Sb' and Sc' indicative of the transmission

25   conditions according to the synchronizing signal
C.Sync, and outputs those information as a trans-
mission-condition imaging signal to display 11
according to the synchronizing signal C.Sync within the

video effective period which will be described later.

This transmission-condition imaging signal is displayed on the display as shown in Fig. 56C.

The construction of the transmission-condition images superimposing device 7T is fundamentally the same as in Fig. 11, but the construction of the image integrator 7-4 is slightly changed in this superimposing device 7T.

Fig. 57 is a block diagram of an example of the image integrator 7-4. This integrator will be described in detail.

The video signal is supplied to an external video sync type synchronizing signal generator 7-4-5a and the adder 7-4-6. The synchronizing signal C.Sync from the generator 7-4-5a is fed to the outside. The adder 7-4-6 adds the imaging signals passed through the gates 7-4-1, 7-4-2, 7-4-3, the signal indicative of the time base scale and guard interval relative to the ghost imaging signal, and the video signal to produce the transmission-condition superimposed video signal Vs. A superimposing position pulse generator 7-4-4a specifies the position at which each imaging signal is superimposed on the video signal.

An example of the addition rates in the adder 7-4-6 will be given. If all signals applied to the adder 7-4-6 are +5 Volts in digital level, the rates of the field-intensity imaging signal, BER imaging signal and ghost imaging signal are 0.2, the rates of the time

base scale signal and guard interval range signal are 0.05, and the rate of the video signal of which the video portion is analog signal of about 0.7 Volts is one.

5   Fig. 58 shows one example of the waveform of the transmission-condition superimposed video signal Vs. From Fig. 58, it will be seen that the ghost imaging signal Psc, field intensity imaging signal Sa0 through Sa5, and BER imaging signal Sb0 through Sb5 are

10 superimposed on the VBL period of one line.

          Since the ghost imaging signal is super-imposed in analog level, the amplitude of the ghost waveform can be expressed by continuous curves with peaks. The field intensity level and BER can be

15 expressed by binary values of which "0" or "1" indicates the presence or absence of the amplitude. That is, the presence or absence of amplitude is expressed by value "0" or "1" of digitized information.

          Fig. 59A is a block diagram of an embodiment

20 of the field-intensity-to-image converter 7-1. This converter will be described.

          The control signal Sa indicative of a field intensity is supplied to, and converted by the A/D converter 7-1-1 into the digital signal DSa of, for

25 example, 6 bits. The signal DSa indicative of the field intensity is fed to, and converted by the decoder (DEC) 7-1-2 into, for example, all six signals of DSa0 through DSa5. The output signals DSa0 through DSa5 are

fed to one terminals of the six AND gates (AND) 7-1-4, respectively. The six output signals from the AND 7-1-4 are supplied to the OR gate (OR) 7-1-5. The synchronizing signal C.Sync is fed to the superimposing

5   position pulse generator 7-1-3a, which then generates associated superimposing position pulses a0 through a5 in synchronism with the synchronizing signal C.Sync. The pulses a0 through a5 are supplied to the other terminals of the AND 7-1-4, which then take the logical

10   products of them and signals DSa0 through DSa5.

If the signal DSa indicative of the field intensity is 00h, or 0 in decimal notation, only the signal Da0 becomes level "High", and thus only the product of the pulse a0 and signal DSa0 is level

15   "High", with the result that only the signal DSa0 of the position corresponding to the pulse a0 is produced. If the signal DSa is 03h, or 3 in decimal notation, the products of DSa0 through DSa3 and a0 through a3 are level "High", so that the signals DSa0 through DSa3 of

20   the positions corresponding to the pulses a0 through a3 are produced. Then, those output signals from the AND are logically processed in the OR 7-1-5 to produce the field intensity imaging signals Sa0 through Sa5.

Here, If the pulse a0 corresponds to the

25   position of the 12-th H, and the 512-nd through 520-th sample, pulse a1 the position of the 12-th H, and 521-st through 529-th sample, and pulse a5 the position of the 12-th H, and the 540-th through 548-th sample, the

field intensity imaging signal Sa0 through Sa5 is superimposed on the VBL period, out of the video effective area, of the video signal as shown by the raster scanning screen of Fig. 59B.

5   Fig. 60A is a block diagram of an embodiment of the BER-to-image converter 7-2. This converter will be described.

The signal Sb indicative of BER is supplied to, and converted by the A/D converter 7-2-1 into the
10   digital signal DSb of about 3 bits. The signal DSb indicative of the BER is converted by the decoder (DEC) 7-2-2 into, for example, all five signals DSb0 through DSb4.

The output signals DSb0 through DSb4 are fed
15   to one input terminals of the five AND gates (AND) 7-2-4. The five output signals from the AND 7-24 are supplied to the OR gate (OR) 7-2-5.

The synchronizing signal C.Sync is supplied to a superimposing position pulse generator 7-2-3a,
20   which then generates pulses b0 through b4 for super-imposing the BER signal according to the timing of the synchronizing signal C.Sync.

The pulses b0 through b4 are fed to the other input terminals of the AND 7-2-4, which then take the
25   logical products of the signals DSb0 through DSb4 and the pulses b0 through b4. Here, if the BER signal DSb is 00h, or 0 in decimal notation, only the signal DSb0 is level "High", and thus only the product of the pulse

b0 and signal DSb0 is level "High", so that the signal DSb0 of the position corresponding to the pulse b0 is produced. If the signal DSb is 03h, or 3 in decimal notation, the logic products of the DSb0 through DSb3 and b0 through b3 are level "High", with the result that the signals DSb0 through DSb3 of the positions corresponding to the pulses b0 through b3 are produced.

The superimposing position pulse generator 7-2-3a, if it is for NTSC, makes logical processing by use of the 1/910 frequency dividing counter that counts at a clock of 14.3 MHz and is reset with a H-period, and the 1/525 frequency dividing counter that counts at a clock of 1/2 H and is reset with V-period.

Thus, as, for example, illustrated on the raster screen of Fig. 60B, the b4 signal corresponds to the position of the 12-th H, and 560-th through 567-th sample, and the b3 signal the position of the 12-th H, and 568-th through 575-th sample. The b2 signal corresponds to the position of the 12-th H, and the 576-th through 583-rd sample, the b1 signal the position of the 12-th H, and the 584-th through 591-st sample, and the b0 signal the position of the 12-th H, and the 592-nd through 599-th sample. Therefore, at this time, the BER imaging signal Sb0 through Sb4 is superimposed on the VBL period, out of the effective area, of the video signal as shown in Fig. 60B.

Fig. 61 is a block diagram of an embodiment of the ghost-to-image converter 7-3. This converter

will be described.

The correlation output signals indicative of the ghost status is supplied to, and converted by the A/D converter 7-3-1 into the digital correlation output signal DSc of 8 bits. This signal DSc is fed to the FIFO 7-3-2. The pulse FSTrc of frame period is supplied to the write-in reset terminal of the FIFO 7-3-2. The digital correlation output signal D'Sc from the FIFO 7-3-2 is fed to the D/A converter 7-3-7. The output from the D/A converter 7-3-7 is produced as the ghost imaging signal Psc. The synchronizing signal C.Sync is supplied to the timing pulse generator 7-3-3.

The generator 7-3-3 responds to the synchronizing signal C.Sync to generate the read reset signal RRST and read enable signal RE, and supply them to the FIFO 7-3-2.

Fig. 62 is a timing chart for the relation among the signal C.Sync, signal RRST, signal RE and ghost imaging signal Psc. The operation of the converter will be described.

The timing pulse generator 7-3-3 generates the reset signal RRST at the time of the 12-th H, and the 128-th sample in each video period, so that the FIFO 7-3-2 can be made ready to read the written contents from the beginning end. In addition, it generates the RE signal that becomes level "Low" at the time of the 12-th H, and the 130-th through 400-th sample, so that the contents (D'Sc) written in the FIFO

7-3-2 can be read in turn according to this signal.

The readout signal D'Sc is converted by the D/A converter 7-3-7 into the analog ghost imaging signal Psc, which is produced in the VBL period of each

5 video period.

Fig. 63A is a block diagram of the super-imposed information extractor & transmission-condition-to-image converter 7R as another example. This converter will be described.

10 The superimposed information extractor & transmission-condition-to-image converter 7R to which the video signal Vs' in which the transmission-condition information sa0' through sa5', sb0' through sb4', Psc' are superimposed on the VBL period is

15 supplied has a superimposed field-intensity extractor & field-intensity-to-image converter 7-1V, a superimposed BER extractor & BER-to-image converter 7-2V, a super-imposed ghost extractor & ghost-to-image converter 7-3V, and an image integrator 7-4V.

20 The synchronizing signal C.Sync is derived from the video signal Vs' in the image integrator 7-4V, and supplied from the image integrator 7-4V to the superimposed field-intensity extractor & field-intensity-to-image converter 7-1V, superimposed BER

25 extractor & BER-to-image converter 7-2V, and super-imposed ghost extractor & ghost-to-image converter 7-3V.

The outputs VOSa, VOSb, VOSc from those

extractor & converters 7-1V, 7-2V, 7-3V are supplied to the image integrator 7-4V.

The extractor & converters 7-1V, 7-2V, 7-3V find, in synchronism with the synchronizing signal
5   C.Sync, the periods of the information sa0' through sa5', sb0' through sb4', Psc' that are indicative of the transmission-conditions superimposed on the VBL period of the input video signal Vs', and extracts these information. In addition, those extractor &
10 converters 7-1V, 7-2V, 7-3V convert these information to the associated imaging signals so that they can be displayed on predetermined positions within the video effective period as will be described later.

The image integrator 7-4V unites these
15 imaging signals to form the transmission-condition imaging signal.

Fig. 63B is a schematic diagram showing this transmission-condition imaging signal (Vosa, Vosb, Vosc) fed to and displayed on a display 11 (Fig. 55)
20 within the video effective period of the screen. Thus, since the various different transmission conditions (field intensity-Vosa, BER-Vosb, ghost-Vosc) are displayed within the video effective period of the screen, the director or operator on the studio side
25 distant away from the OFDM transmission system can correctly grasp the transmission conditions, or transmission status.

Fig. 64A is a block diagram of an example of

the superimposed field intensity extractor & field-intensity-to-image converter 7-1V. This converter will be described.

The analog field intensity information sa0' through sa5' superimposed on the 12-th H of the video signal Vs' as described above is supplied to a comparator 7-1V-1, and converted thereby into digital signals DSa0' through DSa5'. These signals DSa0' through DSa5' are serially successive signals with respect to time.

The signals DSa0' through DSa5' are fed to a serial-to-parallel converter (S/P) & latch 7-1V-1, and converted thereby to parallel data DSa [5 : 0] P' of, for example, 6 bits.

The sampled, held parallel output DSa [5 : 0] P' from the S/P & latch 7-1V-1 is supplied to a decoder 7-1V-2. The decoder 7-1V-2 converts the DSa [5 : 0] P' of 6 bits to, for example, 64 pieces of data, DSa63' through DSa0'.

The outputs DSa63' through DSa0' from the decoder 7-1V-2 are supplied to 64 AND gates 7-1V-4, respectively. The outputs from the 64 AND gates 7-1V-4 are fed to an OR gate 7-1V-5. The synchronizing signal C.Sync is supplied to a superimposed field intensity extractor & display position pulse generator 7-1V-3. This extractor & pulse generator 7-1V-3 responds to the synchronizing signal C.Sync to generate the extraction pulse Psa and display position pulses a63' through a0'.

A total of six pulses of the extraction pulse
Psa are generated during the interval, for example,
from the 512-nd to 548-th sample of 12-th H out of the
video effective period. The display position pulses

5   a0' through a63' become level "High" during the
positional range, for example, from the 200-th to 203-
rd horizontal scanning line, and from the 384-th to
640-th sample.

That is, the signal a0' is displayed at the

10 position of the 200-th through 203-rd H (Horizontal
line), and the 384-th to 387-th sample. The signal
a62' is displayed at the position of the 200-th through
203-rd H, and the 632-nd through 635-th sample.

The signal a63' is displayed at the position

15 of the 200-th to 203-th H, and the 637-th through 640-
th sample.

These pulses a0' through a63' are supplied to
the other input terminals of the AND gates 7-1V-4. The
AND gates 7-1V-4 produce the logic products of the

20 pulses a0' through a63' and DSa63' through DSa0',
respectively.

Fig. 64B is a schematic diagram showing the
extraction pulse Psa and display position pulses a0'
through a63' displayed on the screen.

25   Fig. 65A is a block diagram of an embodiment
of the superimposed BER extractor & BER-to-image
converter 7-2V. This extractor & converter 7-2V will
be described.

The analog BER information Sb0' through Sb4' superimposed on the 12-th H of the video signal Vs' as described above are supplied to a comparator 7-2V-1, and converted thereby to digital signals DSb0' through

5 DSb4'. The signals DSb0' through DSb4' are a total of five serially successive signals with respect to time. The signals DSb0' through DSb4' are supplied to a serial-to-parallel converter (S/P) & latch 7-2V-2, and converted thereby to, for example, a total of five

10 parallel pieces of data DSb0' through DSb4'.

The signals DSb0' through DSb4' from the S/P & latch 7-2V-2 are fed to five AND gates 7-2V-4. The five outputs from the AND gates 7-2V-4 are supplied to an OR gate 7-2V-5.

15 The synchronizing signal C.Sync is supplied to a superimposed BER extractor & display position pulse generator 7-2V-3. The extractor & generator 7-2V-3 responds to the synchronizing signal C.Sync to generate display position pulses b0' through b4' during

20 the video effective period. This extractor & generator 7-2V-3 also generates the extraction pulse PSb' at the 12-th H out of the video effective period.

Fig. 65B is a schematic diagram showing the extraction pulse PSb and display position pulses b0'

25 through b4' displayed on the screen.

The superimposed BER extractor & display position pulse generator 7-2V-3, if it is used for NTSC, makes logic processing by use of a 1/910

frequency dividing counter that counts at a clock of 14.3 MHz and is reset with H-period, and a 1/525 frequency dividing counter that counts at a clock of 1/2 H and is reset with V-period.

5　　　　Consequently, for example, the signal b4' is displayed at the position of the 80-th through 96-th H, and the 512-nd through 526-th sample. The signal b3' is displayed at the position of the 80-th through 96-th H, and 528-th through 542-nd sample. The signal b2' is 10 displayed at the position of the 80-th through 96-th H, and the 544-th through 558-th sample. The signal b1' is displayed at the position of the 80-th through 96-th H, and the 560-th through 574-th sample. The signal b0' is displayed at the position of the 80-th through 15 96-th H, and the 576-th through 590-th sample.

Fig. 66A is a block diagram of an embodiment of the superimposed ghost extractor & ghost-to-image converter 7-3 V. This extractor & converter 7-3 V will be described.

20　　　　The ghost information PSc' superimposed at the 12-th H of the video signal Vs' as described above is supplied to an A/D converter 7-3V-1. The output D'Sc from the A/D converter 7-3V-1 is fed to the write-in data terminal of an FIFO 7-3V-2. The output D'Sch 25 from the FIFO 7-3V-2 is supplied to a comparator 7-3V-4. The output LE from the comparator 7-3V-4 is supplied to a gate 7-3V-5.

The synchronizing signal C.Sync is supplied

to a CK reproducer 7-3V-6, an HD extractor 7-3V-7, and
a VD extractor 7-3V-8. The output CK from the CK
reproducer 7-3V-6 is fed to a counter 7-3V-9. The
output WE from the counter 7-3V-9 is supplied to the WE

5   terminal of the FIFO 7-3V-2.

The output HD from the HD extractor 7-3V-7 is
supplied to a counter 7-3V-10. The output C-S from the
counter 7-3V-10 is fed to a decoder 7-3V-3. The output
VD from the VD extractor 7-3V-8 is supplied to an H-

10   counter 7-3V-11. The output C-H from the H-counter 7-
3V-11 is supplied to the decoder 7-3V-3 and a decoder
7-3V-12. The output RRST from the decoder 7-3V-3 is
supplied to the RR terminal of the FIFO 7-3V-2.
Similarly, the output RE from the decoder 7-3V-3 is fed

15   to the RE terminal of the FIFO 7-3V-2.

The control signal WRST for use in extracting
the ghost information PSc' is supplied from the decoder
7-3V-3 to the write-in reset terminal WR of the FIFO 7-
3V-2. The WE is fed to the write-in control terminal

20   WE of the FIFO 7-3V-2. The output Dhh from the decoder
7-3V-12 is fed to the comparator 7-3V-4.

The CK reproducer 7-3V-6 reproduces the CK
of, for example, 14.3 MHz on the basis of the input
synchronizing signal C.Sync. The HD extractor 7-3V-7

25   extracts the H-period component from the synchronizing
signal C.Sync, and produces the HD signal of H-period.
The counter 7-3V-10 is reset by the HD signal and
produces the counter signal C-S of which the value

increases at every CK period.

The VD extractor 7-3V-8 extracts the V-period component from the synchronizing signal C.Sync, and produces the VD signal of V-period. The H-counter 7-

5 3V-11 is reset by the VD signal, and produces the counter signal C-H of which the value increases at every H-period.

The decoder 7-3V-3 receives the counter signals C-S and C-H, and produces on the basis of those

10 signals the read reset signal RRST that becomes level "Low" for 1 CK period at every Horizontal scanning line during the interval from the m-th scanning line to the (m+n)-th scanning line. This RRST initializes the read address to the FIFO 7-3V-2 into 0. The decoder 7-3V-3

15 also produces the read enable signal RE that becomes level "High" during the interval, similarly, from the m-th scanning line to the (m+n)-th scanning line, and advances the read address to the FIFO 7-3V-2 so that the D'Sch as the correlation calculated signal Sc can

20 be read from the FIFO 7-3V-2.

The decoder 7-3V-12 responds to the input counter signal C-H to generate the Dhh that becomes level 1a at the m-th scanning line, then reduces its level by i at every horizontal scanning line, and

25 becomes 1 b at the (m+n)-th scanning line. The comparator 7-3V-4 compares the D'Sch as the correlation calculated signal Sc and the Dhh, and produces output LEh that becomes level "High" when the condition of

D'sch > Dhh is satisfied. Fig. 66B shows the ghost imaging signal VOSc superimposed on the reproduced picture of the video signal on the display screen.

Fig. 67 is a timing chart of the various
5 signals mentioned above. The extractor & converter 7-3V will be further described.

The WRST signal is generated, for example, at the 100-th sample of the 12-th H of the video signal Vs' on which the information is superimposed at the 12-
10 th H, and initializes the FIFO 7-3V-2. The WE signal is generated that becomes level "Low", for example, in the interval from the 128-th to the 256-th sample of the 12-th H of the video signal Vs' on which the information is superimposed at the 12-th H, so that the
15 D'Sc can be written in the FIFO 7-3V-2.

The RE signal is produced during the interval from the m-th to the (m+n)-th sample at every H-period, so that the written contents can be read sequentially one by one. The signal D'Sch read out at every H-
20 period of the video signal is compared with the value Dhh at every horizontal scanning line, so that the comparator generates the LE signal that becomes level "High" when the condition of D'Sc < Dhh is satisfied.

In order to prevent the LE signal from being
25 generated in the blanking period, the GI signal that becomes level "Low" during the blanking period is used to forcibly make the ghost imaging signal VOSc level "Low" in the blanking period. The higher the level of

the Sc signal, the longer the High-level period of the ghost imaging signal.

Thus, the information of the field intensity, BER and reflected wave mixture (ghost) that indicate the transmission conditions, status or situations in the transmission of signals from movable bodies can be transmitted to the studio side distant away from the OFDM transmission system. On the studio side, each piece of the information that indicates each of the superimposed transmission conditions is extracted from the received video signal, and displayed as a transmission-condition imaging signal within the video effective period, so that the director or operator can accurately understand these transmission conditions from the screen.

If the receiving side has no special receiver for the transmitted information indicative of the transmission conditions that require such transmission and displaying system as mentioned above, the operator cannot view the transmission conditions.

Thus, the next embodiment, which will be described below, enables the director or operator to grasp the transmission conditions without any special receiver by expressing the information of transmission conditions in amplitude levels or in pulse width values, and adding, or superimposing them on part of the video signal before the transmission of the information.

Fig. 69 schematically shows one example of the transmission-condition superimposed & continuous signal added video signal that has added therein a signal Asa of the field intensity information Sa

5 expressed by amplitude level intensity and a signal Asb of the BER information Sb similarly expressed by amplitude level.

There is a video waveform monitor that is always taken as an apparatus in the field of the

10 operation on a mobile relaying communicator such as the outside broadcast van. If this monitor is used for the operator to observe only the signal of a line contain- ing the transmission-condition superimposed & continu- ous signal added video signal waveform by the line

15 selection function, the transmission conditions can be viewed or observed without use of the special apparatus (the superimposed information extractor & transmission- condition-to-image converter 7R).

Fig. 68 is a block diagram an example of the

20 construction of the combination of a transmission- condition adder 7Tsub of the invention and the transmission-condition image superimposing device 7T shown in Figs. 55 and 11. This construction will be described with reference to Fig. 68.

25 The video signal that serves to carry the information of the transmission conditions at the time of transmission is generated from a video integrator 7b-4 within the transmission-condition image super-

imposing device 7T, and supplied to the i3 terminal of

a superimposing device 7-8 of the transmission-

condition adder 7Tsub. A transmission-condition super-

imposed & continuous signal added video signal is

5 produced from the output terminal O of the super-

imposing device 7-8.

The field intensity information Sa is

supplied to a field-intensity-to-level converter 7-6 of

the transmission-condition adder 7Tsub and to a field-

10 intensity-to-image converter 7b-1 of the transmission-

condition image superimposing device 7T. The BER

information Sb is supplied to a BER-to-level converter

7-7 of the transmission-condition adder 7Tsub and to a

BER-to-image converter 7b-2 of the transmission

15 condition image superimposing device 7T.

The synchronizing signal C.Sync from the

transmission-condition image superimposing device 7T is

supplied to the field-intensity-to-level converter 7-6

and BER-to-level converter 7-7 of the transmission-

20 condition adder 7Tsub. The outputs Asa and Asb from

the field-intensity-to-level converter 7-6 and BER-to-

level converter 7-7 are supplied to the input terminals

i1 and i2 of the superimposing device 7-8, respec-

tively.

25 The operation of each part will be described.

Like elements corresponding to those in Fig. 11 make

the same operation, and will not be described in

detail.

The field-intensity-to-level converter 7-6 produces, from the input field intensity information Sa, the signal Asa of which the output level (for example, DC value) is changed according to its

5 condition, or field intensity as a field intensity level signal indicative of a field intensity level only during a predetermined period in synchronism with the C.Sync signal.

The BER-to-level converter 7-7 produces, from

10 the input BER information Sb, the signal Asb of which the output level (for example, DC value) is changed according to its condition, or BER as a BER level signal indicative of a BER level only during a predetermined period in synchronism with the C.Sync

15 signal.

The signals Asa and Asb are, specifically shown in Fig. 69, added in part of the non-signal VBL period in order to indicate the field intensity infor- mation Sa and BER information Sb by their levels.

20 Specifically, if the level, or amplitude of the signal Asa is large, the field intensity level is high. If the level, or amplitude of the signal Asb is large, the BER is satisfactory.

The superimposing device 7-8 adds the super-

25 imposed information signals fed to the input terminals i1, i2 and i3.

Fig. 70A is a block diagram of an embodiment of the field-intensity-to-level converter 7-6. This

converter will be described.

The field-intensity information Sa is supplied to a level shifter 7-6-1, and the output Ha from the level shifter 7-6-1 is fed to the terminal i

5 of a gate switch (SW) 7-6-2.

The C.Sync signal is supplied to an addition position pulse generator 7-6-3. The output GATE-Aa from the addition position pulse generator 7-6-3 is fed to the terminal c of the SW 7-6-2.

10 The operation of this converter will be described. The level shifter 7-6-1 generates the Ha of a DC voltage level that is higher than the pedestal level of the added video signal, and that is proportional to the field-intensity information Sa. The

15 addition position pulse generator 7-6-3 generates, in synchronism with the C.Sync, the GATE-As as a control signal for causing the Ha to be superimposed on a predetermined period.

The SW 7-6-2 produces the signal Ha fed to

20 the terminal i as the field-intensity level signal Asa from the output terminal O according to the status of the control signal GATE-Aa.

Thus, the level signal Asa is added to part of the non-signal VBL period as shown in Fig. 70B. The

25 non-signal period can be easily found if it is out of the superimposition timing of the transmission-condition image superimposing device 7T, and thus it is selected to be that period.

Fig. 71A is a block diagram of an embodiment of the BER-to-level converter 7-7 for generating a pulse signal of which the duration is changed according to the BER information.

5   The BER information Sb is supplied to a level-to-time converter 7-7-1, and the output Tb from the level-to-time converter 7-7-1 is fed to the terminal i of a gate switch (SW) 7-7-2. The synchronizing signal C.Sync is supplied to an addition

10 position pulse generator 7-7-3, and the output GATE-tb from the addition position pulse generator 7-7-3 is fed to the terminal c of the SW 7-7-2.

The operation of this converter will be described in detail. The level-to-time converter 7-7-1

15 generates the pulse Tb which has a DC voltage higher than the pedestal level of the video signal to which the BER information is added, and of which the duration is changed in proportion to the BER information Sb. The addition position pulse generator 7-7-3 generates,

20 in synchronism with the synchronizing signal C.Sync, the GATE-tb as a control signal for causing the Tb to be superimposed on a predetermined period. This GATE-tb has a width corresponding to the maximum duration that the time pulse Tb can take.

25   The SW 7-7-2 generates the Tb fed to the input terminal i as the BER level signal Tsb from the output terminal O in accordance with the status of the control signal GATE-Tb, or so that the condition of

GATE-Tb period length > Tb can be satisfied.

Thus, the BER level signal Tsb, as shown in Fig. 71B, is added to part of the non-signal VBL period. The non-signal period can be easily found if

5   it is out of the superimposition timing of the transmission image superimposing device 7T, and thus it is selected to be that period.

If the BER status is better, the duration of Tsb becomes longer. If the BER status is worse, the

10   duration of Tsb becomes shorter.

While the above embodiment employs the field-intensity-to-level converter 7-6 for generating the level signal of which the level is changed in accordance with the amplitude level as shown in Fig. 70A, and

15   the BER-to-level converter 7-7 for generating the level signal of which the level is changed in accordance with the duration of the time pulse as shown in Fig. 71A, the level signals to be generated in the converters 7-6 and 7-7 may be changed in the opposite way to the

20   above, or in accordance with the duration and amplitude of the time pulse, respectively. Or both the level signals may be changed in accordance with any one of the duration and amplitude.

In addition, while the field intensity level

25   signal Asa is added to the digitized field intensity information signal Sa left as shown in Fig. 70B, only the field intensity level signal Asa may be super-imposed on the video signal as shown in Fig. 71B

because both the signals are fundamentally the same field intensity information.

In this case, however, when the superimposed information is extracted on the receiving side, it
5 should be noted that the level or pulse duration indicates the transmission condition.

Fig. 72A is a block diagram showing an example of the construction of the time-to-BER converter 7-2Vr for detecting the pulse duration. This
10 converter will be described. This converter is associated with the superimposed BER extractor & BER-to-image converter 7-2V shown in Fig. 65A.

The video signal Vs' with the field intensity information Tsa and BER information Tsb added is
15 supplied to a trailing-edge detector 7-2Vr-1. The output DT-DOWN from the trailing-edge detector 7-2Vr-1 is supplied to an AND gate 7-2Vr-3. The synchronizing signal C.Sync is fed to a control pulse generator 7-2Vr-5. The output Cu-RST from the generator 7-2Vr-5 is
20 supplied to a counter 7-2Vr-2. The output LT-Gate from the control pulse generator 7-2Vr-5 is supplied to the other input terminal of the AND gate 7-2Vr-3. The output Cu-B from the counter 7-2Vr-2 is fed to a latch 7-2Vr-4. The output from the AND gate 7-2Vr-3 is
25 supplied to the LT-terminal of the latch 7-2Vr-4.

The operation of each element of the converter will be described. The trailing-edge detector 7-2Vr-1 detects the trailing edges contained

in the information-superimposed video signal Vs'. Fig.
72B shows the waveforms of the signals fed and
produced.

5   The trailing-edge detector 7-2Vr-1 detects
the ends of pulse, or trailing edges of signals Tsa and
Tsb irrespective of the kind of the tailing edges of
the input signal.

The control pulse generator 7-2Vr-5 is
responsive to the C.Sync signal to generate the signal
10   LT-Gate that becomes level "High" for the time interval
from t4 to t5 in which the Tsb probably exists, and the
signal Cu-RST that becomes level "Low" during the same
time interval. The AND gate 7-2Vr-3 transmits to the
latch 7-2Vr-4 only the leading edge pulse contained
15   within the time interval from t4 to t5. The counter 7-
2Vr-2 counts only during that time interval to count up
the value with lapse of time. During the other time
interval, since the signal Cu-RST is level 0, the
counter content remains 0.

20   Consequently, the latch 7-2Vr-4 holds that
counted value just at the instant when the signal Tsb
falls off. Thus, the value proportional to the pulse
duration of the signal Tsb can be extracted.

While the embodiments described with refer-
25   ence to Figs. 55 through 72B are related with the
transmission of the video signal with the transmission-
condition image signals including the ghost image
signal being superimposed on the blanking period of the

video signal, the present invention can also transmit
the transmission-condition image signals by other
methods. For example, the transmission-condition image
signals can be transmitted, through another separate

5 channel different from the transmission channel using
the video signal, from the repeater station 53 to the
broadcast station 54 or those image signals can be
transmitted by multiplexing with the video signal, for
example, time-division multiplexing to the broadcast

10 station 54.

Fig. 73 is a block diagram of one example of
the transmission of the video signal as main data and
the transmission-condition image signals via separate
channels from the relay station to the broadcast

15 station. On the receiving side of the relay station,
the transmission-condition image signals of 1 H (a
horizontal period) superimposed on the vertical
blanking period are converted by an AD converter (not
shown) of an AD & time-expansion processor 400 into a

20 digital signal, and the fast digital data of the 1-H
signal is further converted by use of a memory (not
shown) of the processor 400 to a slow digital signal of
one frame period. The next stage, a microwave band FPU
(field pickup unit) 203Ta as a digital type video

25 transmitter has the function to transmit the video
signal as main data and the function to transmit the
other auxiliary data. The converted low-speed digital
signal (superimposed transmission-condition image

signals) corresponding to 1 H period is supplied to a terminal ACin, as the input terminal for the auxiliary data, of the transmitter 203Ta, and transmitted therefrom to the broadcast station.

5   On the broadcast station, the low-speed signal (transmission-condition image signals) corresponding to 1 H period reproduced from the terminal ACout of a digital video receiver FPU 300a is fed to a time-compression & DA processor 401, where it is
10 converted by use of a memory back to the fast signal of 1 H period, and further converted back to the analog signal by a DA converter (not shown). This analog signal is supplied to a transmission signal reproducer 7Ra on the studio side.

15   Thus, according to the embodiments of the invention, since the transmission conditions such as the field intensity, BER and the presence or absence and levels of reflected waves can be transmitted from the OFDM transmission system to other remote places
20 such as studios, and on the receiving side they can be extracted and displayed, the operator even at other remote places can easily and accurately observe the transmission conditions of signals from mobile communicators such as outside broadcast vans.